ATTENTIONAL DEFICITS IN CHRONIC SCHIZOPHRENIA

BY

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For my friends, the people I love:
Iris, Mom, Judy, Kathy, Chris, Jim and Ken K.

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It has been proposed in the literature that although both hemispheres can mediate activation, the right hemisphere is dominant for mediation of activation and intention, a readiness to respond. Activation/intentional and hemispheric processing deficits have separately been found in chronic schizophrenics. Twenty right-handed normal males and twenty right-handed chronic schizophrenics performed nonverbal and verbal visual half-field reaction time tasks to (1) replicate findings of a right hemisphere dominance for activation and (2) determine whether schizophrenics have a hemisphere mediation of intention deficit. Control data supported a right hemisphere superiority for performance on intentional tasks. Faster response times were found for material presented in the left visual half-field than for material presented in the right visual half-field.

Schizophrenics had slower overall reaction times and no half-field asymmetries on intentional tasks. Schizophrenics were further found to have increased response times over blocks of trials. Results were compatible with activation deficit or information processing deficit explanations.

Three additional attentional tasks were performed by subjects to separate out attentionally and non-attentionally deficited schizophrenics. Non-attentionally deficited schizophrenics tended to have faster reaction times than attentionally deficited schizophrenics on the half-field tasks. They additionally were not found to have increased response times over blocks of trials on the verbal half-field task. It was proposed that attentionally deficited schizophrenics have intentional and information processing deficits. Non-attentionally deficited schizophrenics were thought to have slowed information processing.

CHAPTER ONE
INTRODUCTION AND RATIONALE

What is Attention?

In 1890 William James wrote "Everyone knows what attention is." Tichener (1908), more skeptically, wrote that although attention was one of psychology's great discoveries, with it followed a deluge of unrelenting problems. The major problem of defining the various aspects has been tackled by several theorists.

Berlyne (1970) divides attention into two broad behavioral categories of a) intensive attention and b) selective aspects of attention. The first, intensive attention, is the amount of attention the individual gives to the stimulus field as a whole. He described three components of intensive attention. The first component of intensive attention, arousal, is an overall state of the organism ranging from drowsy to agitation. This component is curvilinearly related to the second component, attentiveness. Attentiveness is defined as the degree to which the individual responds to the environment from moment to moment. Attentiveness fluctuates and is highest when at neither end of arousal. When information from several sources converges into a channel and exceeds channel capacity, some information is lost. The third component, the degree of concentration, ranges from concentrated to diffuse and accounts for the amount of information from any one source taken in.

Berlyne's second behavioral category, the selective aspects of attention is defined as the degree to which elements in the field are attended to. Three processes of selective attention are delineated. Exploratory behavior includes sensitizing physiochemical processes within sense organs, muscular-sensory adjustments toward the source, locomotion and manipulation. During exploratory behavior the organism determines which stimuli will reach the receptor. This process augments inflow of information from one source while it excludes other sources. Selective attention, the second process, is viewed by Berlyne as the only process that should be labelled attention. During selective attention the individual singles out a stimulus after the stimuli have been perceived. Berlyne further divides selective attention into three behavioral processes: attention in learning, attention in remembering and attention in performing, all self-explanatory. However, what is not self-explanatory is how one can separately measure these three sub-components. The third process, selective aspects of attention, is defined as abstraction. It is described as a process whereby one selectively attends to certain stimulus properties while ignoring others belonging to the same stimulus, perceiving them through the same sense organs (i.e., shape and not color).

Posner and Bois (1971) divide attention into three components which sound similar to yet simpler than Berlyne's conception: 1) alertness, vigilant attention or arousal which includes a sensitivity to the external world so that parts of the environment may be perceived; 2) selectivity or ability to select information from a single source; and, 3) a limited capacity for processing certain information while excluding and thereby losing or delaying responding to other information.

Pribram and McGuinness (1970) views "attention" as divided into three distinct functional operations. 1) Arousal is the first and has the same characteristics and is synonymous with the orienting response (OR) as identified by Sokolov (1960). 2) Activation is the second component and is a vigilant readiness. The processes as determined by Pribram are mediated by separate neural pathways to be discussed in the next section. Activation is described as a tonic readiness to respond and is a "What's to be done?" reaction. 3) Effort is the third operation and is similarly mediated through a third neural circuit. Effort, the measure of focused attention used to increase or maintain efficiency of information processing, coordinates these two processes in active cognitive functioning. During different types of cognitive processing (categorizing as opposed to reasoning) different combinations of arousal and activation are balanced by effort.

As the many examples cited above demonstrate, the study of "attention" has become fraught with definitional problems. Researchers frequently isolate behaviors experimentally under unique conditions and then define attention in terms which fit their own paradigm. Of course one must label a behavior to identify it, but the confusion is staggering when dealing with so fluid and complex a set of interacting behaviors within the area of attention. Berlyne's divisions are one example. Here overlapping of terminology is clear: Concentration and selective attention in learning and memory would be difficult to separate experimentally. To "concentrate," one must have a stimulus to concentrate on, whether internal or external, and concentration is distinguished from selective attention only by being under intensive attention. Further, although stating selective attention as being the only process which should be termed attention, he uses this word in various forms to describe several processes. The term, as he implies, has become overused and meaningless. Confusion is furthered by investigators labeling behaviors differently. What Berlyne has termed "exploratory behavior" most commonly refers to an orienting response. While Posner and Bois view arousal and vigilance as similar, Pribram views these as processes with separate circuitry. Pribram's "arousal" appears to be closer to Berlyne's exploratory behavior than Berlyne's "arousal." And is Pribram's "vigilant attention" closer to Berlyne's "selective attention" or Berlyne's "concentration"?

The comparisons reflect the current state of the area which one is faced with. This is partly due to the fact that behavioral and neurophysiological research on attention developed separately and remained isolated for many years. Additionally, investigators, within each area developed unique concepts and terminology. Therefore, a multitude of procedures, vocabularies and theories left the area in a muddled, confused state. Only by utilizing reliably reproducible techniques and theoretical positions backed by credible research, can one advance rather than further confuse the area. This will be an important consideration in the development of this paper. Neurophysiological evidence and theories will be reviewed, followed by a summary of cognitive theories to provide a background understanding of the development of experimental procedures and theories used for investigative purposes in the current project.

The Neuroanatomy and Neurophysiology of Attention

Neurophysiological research on attention gained new impetus with the finding that stimulation of the brainstem reticular formation by implanted electrodes (Moruzzi and Magoun, 1949) produces cortical EEG activation. This activation is characterized by increased frequency and desynchronization of the EEG rhythms diffusely over the cortex and is generally referred to as an arousal reaction or activation. It is accompanied by behavioral alerting responses (Lindsley, 1960). Lindsley (1960) has shown that this desynchronization serves to decrease reaction time when warning stimuli are presented in time to produce alpha blocking. Best results were found when warning signals were presented between 400-1000 msecs. before the response signal. Stimulation of the mesencephalic reticular formation had further been found to increase evoked potentials in the visual cortex (Lindsley, 1958) and lateral geniculate bodies (Sokolov, 1960) when visual stimuli were presented. Reciprocally, natural stimulation from widespread areas of the cortex evoked potentials through activation of the reticular formation. Furthermore, lesions in the mesencephalic tegmentum resulted in electrocortical synchronization, characterized by behavioral sleep. Stimulation produced only momentary arousal in the animal (Lindsley, Schreiner, Knowles and Magoun, 1950).

This accumulation of evidence led investigators to believe that an "ascending reticular activating system" was responsible for regulating levels of consciousness. It was thought to be a multineuronal, multisynaptic network of short-axoned cells extending from the medulla to the hypothalamus. It was found to be characterized by tonic, persistent long latency impulses as compared to the classical sensory impulses which are discrete and brief. Activation of this system was thought to occur through collateral pathways from specific or classical sensory pathways and was found to be affected by modality of stimulation and humoral agents. Agents such as pentobarbitol were found to block ascending transmission while leaving impulses through specific sensory pathways unchanged. Adrenaline and carbon dioxide were found to increase activation (Brodal, 1980; Lindsley, 1960).

Sharpless and Jasper (1956) distinguished between a tonic arousal found in the brainstem reticular formation (RF) and a phasic, shortlived arousal obtained by stimulation of the "nonspecific" thalamic nuclei. This nonspecific system, also called the diffuse thalamic projection system (DTPS) (Lindsley, 1960) was felt to receive ascending fibers from the brainstem and project onto the cortex, caudate or striatum or connect with the ventral anterior nucleus (VA) or the reticular nucleus of the thalamus.

Dempsey and Morison (1942) found that with low frequency stimulation of 6 to 12 pulses per second of these diffuse nuclei, an increasingly larger response from the cortex was observed. These recruiting centers, so called for eliciting a gradually increasing number of diverse impulses from parts of the neocortex with low frequency stimulation, evoke electrocortical desynchronization (activation) with high amplitude stimulation. This arousal response was distinguishable from the brainstem activation by having a more topographically limited and shorter lasting response. Furthermore, the brainstem system was found to take precedence over the DTPS and felt to be a tonic protective or adjustive monitoring network while the DTPS was instrumental in specific alerting and selective attention for learning and higher perceputal discriminations.

The existence of an activating system in the brainstem has long since been established. Current research, though, has clarified some anatomical and functional aspects of these pathways. Yet much remains a mystery due to the complexity of the networks involved. It becomes increasingly clear that strict differentiation of diffuse or specific pathways is no longer viable, due to the extent of intercommunication among the different nuclei (Brodal, 1980).

Three groups of nonspecific thalamic nuclei have been identified: 1) intralaminar nuclei, 2) midline nuclei and 3) reticular nucleus. Fibers from medullary, pontine and mesencephalic reticular formation have been traced to these nonspecific thalamic nuclei as well as to the hypothalamus, septal area, caudate and lentiform nuclei as well as to some "specific" thalamic nuclei. Spinothalamic fibers are found to project to nonspecific nuclei. Therefore, a larger network of connections has been established. Interconnections among the midline and intralaminar nuclei, connections from nonspecific to specific sensory nuclei and projections from diffuse nuclei to older cortical lobes such as limbic and entorhinal cortex have been found (Nauta and Kuypers, 1958).

The reticular nucleus is of particular interest. With its unique positioning it has virtually all fibers interconnecting the thalamus and neocortex pass through it. Additionally it sends impulses to specific and nonspecific thalamic nuclei and caudally to superior colliculi and mesencephalic reticular formation. With availability for monitoring thalamocortical and corticothalamic fibers and feedback to brainstem centers, its function appears to be integration and regulation of thalamocortical and corticothalamic activity by sending impulses to specific, nonspecific and brainstem nuclei.

The ventral anterior nucleus has also received attention by its possible function as the final link between nonspecific nuclei and the cortex.

Scheibel and Scheibel (1966) indicate two routes for dorsal reticular formation projection and one ventral route. One dorsal route originates in the reticular formation, traverses to midline and intralaminar nuclei through the reticular nucleus and VA and finally projects to the cortex. The ventral route also originates at the RF, bypassing the thalamus and instead passes through the subthalamus and hypothalamus, projecting finally to the frontal lobes.

Lesions in VA and orbitofrontal cortex have been shown to abolish recruiting responses without altering EEG desynchronization (Skinner and Lindsley, 1967). As mentioned previously, electrocortical activation is terminated instead by mesencephalic lesions (Lindsley et al., 1950). This suggests that the ventral route controls tonic cortical arousal while the dorsal route is responsible for recruiting responses.

Electrophysiology and Behavioral Correlates

It has been known since the 1920's that electrocortical potentials detectable on the surface of the brain are representative of some of the processes involved in shifting attentional states. As seen in the preceding section, these potentials can indicate the state of consciousness and correlate well with behavioral signals. Lindsley (1960) has outlined states of consciousness and the electrocortical and behavioral patterns. Four states of wakefulness as recorded by the electroencephalogram (EEG) are described. The normal, relaxed state of wakefulness is commonly defined by a synchronized pattern of alpha waves consisting of 8-12 waves per second in adults (Berger, 1929). This corresponds with nondirected attention or relaxed alertness and is the optimal alpha state. The alpha rhythm is altered by both external and interal stimulation at which time the subject is considered to be alert attentive. Approximately four tenths of a second after an unexpected stimulation, alpha waves are blocked and low voltage fast activity waves at 18 to 30 per second are seen for several seconds. With repetition the response habituates, and alpha blocking no longer occurs. Berger felt this blockage was due to an active inhibition of unalerted sensory systems (Lindsley, 1960). A state of drowsiness is characterized by reduced alpha waves with occasional slow wave activity. Extreme emotional or excited alertness is characterized by desynchronized fast mixed frequency low to moderate amplitude waves.

Alpha blocking has normally been utilized to define alertness and has been correlated with behavioral measures in normal subjects. Lansing, Schwartz and Lindsley (1959) have shown that an unalerted reaction time was 280 msecs. When the subject was alerted with a warning stimulus from 1/2 to one second prior to the response stimulus, the reaction time was reduced to 206 msecs. This curve paralleled the alpha blocking curve. Fuster

(1958) also found decreased reaction time curves in monkeys when stimulated in the midbrain reticular formation via implanted electrodes.

Luria and Homskaya (1970) also found that the regularity of alpha rhythms is disturbed during an alerting to unexpected external stimuli (orienting response) or by intellectual activity and is reinstated with habituation or cessation or activity. When using stimuli conditioned through verbal pre-instruction, repeated presentations of stimuli do not produce habituation, i.e. reinstatement of alpha rhythms is not observed. Luria and Homskaya view this verbally conditioned response as indicative of orbitobasal frontal regulation of phasic arousal. In patients with mediobasal frontal lesioning, Lurai found an intensification of the alerting response as compared to lateral frontal and posterior cortex lesioned patients. Verbal regulation of the alerting response was not observed in these same mediobasal frontal patients.

Measuring averaged largest positive to averaged largest negative evoked electrical responses after the first 1/2 second post-stimulation, these visually evoked potentials (VEPs) have been used as indicators of selective (directed) attention. Typical paradigms of having subjects count light flashes or just instructing a subject to attend to a stimulus increases the evoked potential (Garcia-Austt, Bogacz and Vanzulli, 1964). Evoked potentials (VEP) were monitored through implanted electrodes in parietal, occipital and RF areas. EPs were found to increase with counting procedures (Guerrero-Figueroa and Heath, 1964). Therefore, verbal instruction caused larger VEPs than passive attending to sensory stimulation. General findings correlating

VEPs with RT have found larger VEP amplitudes with shorter RT (Donchin and Lindsley, 1966). One component of the VEP occurring 57 msecs. post-stimulation which correlated with RT is suggested as indicative of RF involvement since RF processing of visual information requires 50 msecs. In vigilance tests spanning 1 1/2 hours, VEP amplitudes decreased as efficiency decreased (Haider, Spong and Lindsley, 1964).

These results were not replicated consistenty (Spong, Haider and Lindsley, 1965). Several problems in interpretation of results are pointed out. Evoked potentials are influenced by many organismic (i.e., state of the organism) as well as by stimulus variables. Sensory modality, stimulus intensity, regularity of stimulus presentation, significance of stimulus to the subject, position of electrodes, age, sex and psychopathology all affect results (Tecce, 1970). Individual differences account for a large part of discrepant results. Mental set during an experimental period, wandering eyes and individual background alpha frequencies all contribute to negative findings. Hopefully, though, with meticulous control of these variables, the attentional variable can be successfully studied.

Another approach to the study of electrocortical components of arousal/attention/intention has employed the averaged evoked slow wave potentials called contingent negative variation (CNV) coined by its discoverer Grey Walter (1938). This surface negative potential is typically recorded during the preparatory interval between a warning stimulus and response stimulus of RT tasks. Prior to the warning stimulus a baseline potential is observed. Following the warning stimulus a short-lived increase in wave amplitude is seen after which the potential quickly drops to an extreme negative amplitude, slowly increasing positively to the point of response stimulus onset. It is best recorded over frontal areas. It has been commonly called the "expectancy wave" (Lynn, 1966) as Walter suggested, although other interpretations include conscious anticipation to perform a motor act, motivation or selective attention. Luria and Homskaya (1970) interpret these responses as evidence for phasic arousal regulation by baseomedial frontal cortex.

Tecce (1970) has found that having subjects perform mental arithmetic during the preparatory interval decreases CNV amplitude. Over successive trials during which response clicks became increasingly less audible, the CNV amplitude variability decreased and overall amplitude increased. He interprets these findings as support for selective attention. He finds motivation and arousal to not account for CNV amplitude. He offers results of decreased CNV amplitudes during trials with distraction. Subjects reported exerting more effort. Heart rate increased during this period. These results suggested that CNV amplitude does not have a monotonic relationship with arousal and that selective attention could better explain the data. The same phenomenon occurred when attention was divided between inner and outer events. Jouvet (Lindsley, 1960) studied surface (occipital) and optic radiation EEGs during selective visual attention and distraction at the time of operation. The subject was asked to attend to and count light flashes. The surface EEG showed increased rapid low voltage activity at the start and a decrease over time. Subcortical visual responses did not decrease. When a distracting stimulus was presented through another modality, the subcortical response decreased and almost disappeared. This was interpreted as a suppression and interaction by the competing modality. The inhibition was suggested as occurring at the lateral geniculate body or retinal level through reticular system control. Mental calculation as a distractor produced similar results. This corroborates with previously mentioned reticular adjustive and protective functions. Therefore, although Tecce can claim attentional shifting, reticular overseeing cannot be overlooked. Tecce himself found a decrease in hippocampal responses to centromedian thalamic stimulation when mental calculations were required. Similar results were found with RF implants.

Neurophysiological Models of Attention

Sokolov

Utilizing these and similar findings concerning the neuroanatomy of attention and activation, several models have been proposed. Perhaps best known and comprehensive is that proposed by Sokolov (1960). Sensory impulses following stimulation, pass to both the cortex and reticular formation via classical sensory tract and afferent collateral pathways, respectively. If the information is novel or significant as judged by comparing it to existing neuronal traces of stimuli (neuronal models), the cortex sends excitatory impulses to the reticular formation. Afferent collateral excitation and cortical impulses result in eliciting an OR at the RF. If the stimulus is familiar (matches an existing model) the cortex sends no excitatory impulses to the RF and incoming afferent collateral excitation is blocked, i.e. habituation. In the case of an OR, concomitant behavioral, somatic and autonomic components result. Turning in the direction of the stimulus, pupil dilation and photochemical changes in the retina result, thereby lowering light sensitivity threshold and lowering auditory threshold from 4 to 10 db facilitating sensory sensitivity, and changes in skin resistance, measured by the galvanic skin response (GSR), occur. Autonomic nervous system (ANS) changes include an overall increase in skeletal musculature tonicity which can be witnessed by (EMG) electromyographic activity. Vasodilation in the head and vasoconstriction in the extremities occur. Respiration changes include a delay and a subsequent increase in amplitude and decrease in frequency. Heart rate, as measured by a cardiotachometer, is found to decrease. Electroencephalographic (EEG) recordings of electrical rhythms in the brain show faster and lower amplitude activity. As pointed out by Sokolov, not all of these changes occur in each individual, which has complicated research findings discussed later in this paper. Heilman and Valenstein (1972) have a similar model which will be discussed later.

Pribram and McGuinness

Pribram and McGuinness (1970) also recognize the importance of cortico-reticular pathways, although their arousal-attentional model and circuitry is somewhat different. As previously mentioned, "arousal" and "activation" are the two mechanisms which are regulated by exerting "effort" to control attention to inner or outer events.

Arousal is considered a "what is it" phasic reaction to a stimulus which is either facilitated or inhibited. The control of these reactions centers on the modulating amygdala which is involved in both the facilitatory circuit (dorsolateral frontal cortex amygdala lateral hypothalamic area median raphe' mesencephalic reticular formation) and the inhibitory (orbitobasal frontal area amygdala medial hypothalamus) circuits. Both systems are serotonergic and collectively referred to as the "stop mechanism."

The "go mechanism" is an activation or "what's to be done" reaction centering on the basal ganglia, involved with the more lateral hypothalamic tracts such as the medial forebrain bundle and brainstem regions including the locus ceruleus and periaqueductal grey structures. This system is a tonic catecholaminergic circuit.

The hippocampus organizes the relationship of these two systems so that arousal will occur without activation for an orienting response; activation can occur without arousal during vigilant attention; and both occur during a defense reaction. Hippocampal balance of these two circuits requires effort in facilitating or inhibiting neurochemical information flow. Paralleling Sokolov's neuronal model for processing information, Pribram and McGuinness propose that this "registration" or fine tuning occurs in the frontal areas. Feedback to the reticular formation is not controlled cortically as Sokolov suggests, but by the hippocampal circuits as mentioned. Vigilant attending is considered an activation process, while the hippocampus inhibits the arousal circuits, and selective attention is viewed as a categorizing response entailing first arousal and secondly activation. Thompson and Bettinger (1970), though, have found evidence suggesting that gating of sensory information is accomplished solely by the cortex without limbic system involvement.

Hernandez-Peon (1966), on the other hand, differentiates between two types of attention. One is involuntary, or "wakefulness of necessity" and is evoked by environmental sensorial activity. Unlike the voluntary or "auto-evoked" type of attention which leads to memory, concentration and thinking, this reflexive attention involves the rostral brainstem RF sensory pathways and collaterals and subcortical CNS, not necessitating use of the cortex. In both types of activity the brainstem RF acts as the central regulatory structure, exerting inhibitory or facilitatory influences on all specific sensory pathways.

As mentioned earlier Posner (1975) suggests three main divisions based on behavioral and electrophysiological work. The first is alertness and is considered a general state of receptivity to stimuli. Two levels of alertness have been found. The first is a tonic alertness which varies diurnally. Carbohydrate steroid levels are proposed as effecting primary cortical neurons and thereby shifting sensory thresholds. A second phasic alerting from subcortical mechanisms is produced when an initial warning stimulus is presented. He views the CNV as representative of this phasic alerting. The suspension of autonomic activity i.e. slowed HR, decreased eye blinking, decrease in motor movement, is further evidence of such alerting.

Borrowing from information processing theory (Broadbent, 1970), Posner finds that a warning stimulus not only alerts the subject but also provides the subject with selective information, the second main division of attention. The selected information involves either a stimulus set or a response set. The stimulus set involves the modality of entry, picking out critical stimulus characteristics. A stimulus set takes precedence with rapid stimulus presentation. A response set occurs when verbal instruction has determined which will be the significant stimulus. Meanwhile, unselected material undergoes classification by the cortex. The differential handling of selected and unselected information is detectable 90 msecs. after presentation at the primary sensory cortex.

The third division is a conscious effort which facilitates passage of the selected information into a limited capacity system of processing while inhibiting attention to other stimuli. This is found to be detected 150-500 msecs. post-stimulus presentation, or at the p-300 wave. This process is said to correlate with conscious awareness and retention for future response sets. Hink and Hillyard (1978) find the N_1 component measured 90-160 msecs. post-stimulation to be indicative of stimulus set and the p-300 wave to be indicative of response set parameters. They equate response set selection as representing information processing.

Conflicting theoretical positions here are again due to varied methods and subject pool. A mixture of lesion and electrophysiological methods on single cell, cats, monkeys and humans has been utilized. This would result in different findings dependent on 1) whether a lesion or stimulation was the independent variable and 2) the differing neurophysiologies of these animals. It appears that certain general conclusions can be drawn from the data in reference to humans: 1) the ARAS has a prominent role in determining the level of tonic arousal and alerting, 2) the ARAS has important connections to and from the cortical mantle through connections with thalamic nuclei and alternately via the subthalamus and hypothalamus, 3) the cortex processes specific incoming sensory information determining whether an orientation reaction will occur, through these same connections and 4) the ARAS and thalamic nuclei are intricately involved with readying or priming the individual for responding to the environmental cues which the cortex has initially received information from. Any attentional process involving more than a purely reflexive response will entail cortical involvement.

Cognitive Theories of Sustained Attention

With the advent of World War II, vigilance or sustained attention research gained new emphasis from a group of experiments involving a radar watch for submarine signals from aircraft (Broadbent, 1971). A rapid decline of performance was found after only one-half hour of watching. The fatigue was found to be avoided by stimulants, rest periods and feedback of performance. Additionally, if the stimulus remained in view until responded to, performance did not decline although it remained at a lower level of efficiency throughout (Broadbent, 1971).

Four theoretical viewpoints evolved to explain these and subsequent research results (Broadbent, 1971). These include 1) inhibition theory,

2) expectancy theory, 3) arousal theory and 4) filter theory. For example, Mackworth's (Broadbent, 1971) inhibition theory postulates that the response becomes extinguished through nonreward. Mackworth's theory attempts to account for the decrease in performance seen over time, by including the importance of motivation as a factor. Inhibition occurs after a response to a signal receiving no reward and decreases in time until the next signal. However, Deese (1955) found that if signals are presented at a more frequent rate, nonrewarded performance was improved. Furthermore, this theory cannot account for the reaction time data by Broadbent, showing performance to remain at low but steady state levels.

Expectancy theory (Deese, 1955) could explain good performance with frequent stimulus presentation by stating that a response was more likely if a stimulus was probable from the past incidence of a signal. This accounted for unexpected signals receiving poor response. Baker (1963) stated that during the watch, the efficiency of the reaction time was determined by the average probability of signal appearance throughout the task. Within a particular time interval after the last signal, stimuli appearing at too long or too short an interval are less likely to be noticed. Uncertainty decreased performance. Over time a vicious cycle occurs wherein more and more signals are missed which lowers expectancy of signals to occur.

Gaining impetus from Hebb's stimulus deprivation experiments illustrating loss of efficiency through reduction of stimulation, a third position, the activation or arousal theory was proposed. The observed decrement in performance over repeated trials was attributed to a lowered arousal state due to insufficient stimulation over time. This also accounted for better (McGrath, 1963) performance observed when irrelevant stimulation was added and when subjects took breaks, stood or stretched. However, the theory could not account for better performance found to auditory signals when the subject was blindfolded. Independent physiological measures of arousal such as skin conductance, hear rate and muscular tension did provide substantial evidence that when the subject was over or under-aroused, performance suffered.

Finally, the fourth theory, Broadbent's (1958) filter theory was applied to problems in vigilance and continuous performance. In this theory, environmental information is brought in through the sensory organs and only part of this information is selected and passed to centers in the brain which organize a response. Information is sent through a selective filter, then through a "P system," a limited capacity channel, and ultimately to long term memory. Since the P system can only absorb a certain amount, the filter admits only a part of the information and the rest is held in an "S system," or storage system, for a short time. Occasionally irrelevant information is sent in and relevant information is not obtained at this time. The content of the information taken in is dependent on the stimulus characteristics noted by Berlyne, i.e., intensity, pitch, novelty and manner in which the information is fed to the individual. He explains poor performance as due to momentary shifts from relevant information. Although explaining poor performance on discrete trials, this theory does not explain the decrement over time in vigilance tasks. Also, while explaining the decrement in performance at slow event rates as a filter shift and improved performance when an auditory and visual stimulus occurred together, these results could also be compatible with the arousal theory.

Neisser rejected the filter theory due to the inability of intrusions to occur from the nonselected messages. Instead he proposes that a preliminary identification is carried out passively by pre-attentive filters working in parallel. The echoic and iconic memories are the storage levels at which point the preattentive filters worked. Then the material is analyzed by a synthesis of inner speech and a reconstruction of stimulus input, through auditory attention. Therefore, irrelevant speech is only passively analyzed and not constructed as selected material is. This "analysis-by-synthesis" is controlled by contextual cues extracted preattentively. Yet preattention can pick up cues such as one's name as a simple feature and not need to synthesize it. Broadbent subsequently agreed with this and changed his position to state that the filters weaken and not altogether block unwanted messages (Neisser, 1967).

Treisman (1960) also concluded that the filter could not be an all or none concept due to apparent intrusions from the neglected message in "shadowing" experiments. She felt that the filters attenuate unwanted messages and that filtering occurs during recognition of stimuli, which is an "activation of an internal representation." According to importance of the stimulus, more or less information is necessary for activation. Therefore, messages such as one's name would readily be recognized as in the "cocktail party effect."

Investigators questioned whether a decrement of sensitivity actually occurred in vigilance tasks, due to evidence from signal detection theory

(SDT) that using the proportion of detected stimuli as a measure of sensitivity incorporated sensitivity as well as the subject's response criterion (1970). Utilizing SDT, one can obtain independent measures of each. The hypothesis was that although the sensitivity remained the same, the response criterion became more conservative (increase in B) due to a decreased expectation of stimulus occurrence producing fewer "false alarms" and correct detections. The expectation would decrease as the subject became more familiar with the task. Egan, Greenberg and Shulman (1961) verified this hypothesis by utilizing a power function known to describe the hit and false-alarm relationship called the receiver-operating-characteristic (ROC) curve. While manipulating the subjects decision criteria, the obtained sensitivity index (d') remained the same.

Further research revealed that visual tasks necessitating a high rate of continuous vigilance does create a decline in d' (lapse of attention) as well as a more stringent response criterion, while tasks allowing short breaks will remain constant in sensitivity although an increase in false alarm rate (B) occurs (Simpson, 1970).

Therefore, although ROC curves were found to provide evidence for decreased sensitivity during continuous tasks, discrete-trial task performance was found to suffer due to changes in subjective criterion. This evidence would leave the filter theory powerless since it is based on reaction time experiments. Broadbent, though, points out that d' is lower in vigilance tasks for the same signal used in psychophysiological conditions, leaving unexplained extra randomness within the observer. Furthermore, Muichterlein points out that while normal distribution curves with equal variance can be presumed to hold for pure light and tone stimuli, little evidence exists that this holds true with more complex stimuli (Garmezy, 1978).

Posner, Snyder and Davidson (1980) found that signal detection theory may not be useful for assessing differential effects of attentional mechanisms when subjects are informed about incoming stimuli prior to presentation. He found that knowledge about incoming stimuli (content or position in attentional field) did not simply change the criterion for response but affected central attentional processes. He further found that attentional and visual sensory mechanisms closely interact but are separate mechanisms. By assuming one central mechanism for detection, information on differential processes may be lost when assuming all other variation is due to response criterion on tasks not strictly sensory detection.

One can conclude that no one behavioral theory of vigilance is a sufficient explanation alone, although arousal theory, backed by psychophysiological measures, an expectancy theory and a filter theory are necessary components.

Along with sustained attention, selective attention has been the other major division of attention which has attracted behavioral study.

As one can see, cognitive-behavioral research emphasizes the cortical operations. While physio-anatomical considerations and attentional divisions can remain purely theoretical, the strength of the research lies in utilizing human subjects. Specific subject or patient groups can be studied and compared to normal subjects. One must be cautious when extrapolating from lesioned patients, though, for the deficiency one sees is not simply the function of the lesioned area but how the rest of the brain functions on that task in the presence of a lesion. Many times other areas take on the lost function and some rerouting takes place in time. Further complications entail the rest of the brain in acute lesions.

In studying chronic diseases, changes are subtle and slow in developing. In severe mental disorders, the process is so slow that originally these diseases were thought of as "functional" or totally environmentally produced. Now, clear indicators show that one of these severe disorders, chronic schizophrenia, has definite genetic, biochemical and psychophysiological components from prospective and retrospective studies (Roff and Ricks, 1970). Several of these components link chronic schizophrenia to reticular-cortical attentional pathways. Although it has been known that in chronic schizophrenia, cortical perceptual and attentional deficits were present, only recently have subcortical components been suggested, as reticular-cortical connections and neurotransmitters are elucidated and chemicals such as Chlorpromazine understood (Mirksy and Kornetsky, 1972).

In the next few sections the historical development of studying attentional deficits in schizophrenia and ultimate conceptualizations of schizophrenia as a cortico-subcortical brain disease are traced.

Attentional Deficits in Schizophrenia

Through clinical observation, scientists first noted the attentional problems of schizophrenics. Kraepelin (Zubin, 1975) in 1913, wrote that he noticed "a certain unsteadiness of attention" but that, "on the other hand, rigid attachment of attention may often develop over a longer time-span." Bleuler (1950) also recorded this inability to apply what he called Aufmerksamkeit, or active attention, which is the sustenance, direction and concentration of effort. More recently McGhie (1970) described examples of the acutely disturbed schizophrenic as unable to concentrate, highly distractible and having every environmental stimulus grip his attention without having the ability to shut these stimuli out.

To systematically study these deficits, investigators utilized the theories and procedures of attention reviewed above (Shakow, 1963; Venables, 1977; Kornetsky and Orzack, 1978; and Steffy and Galbraith, 1973). Results suggest that schizophrenia can be characterized as having any number of deficits or dysfunctions in arousal, selective attention, span of attention, sustained attention, active, inactive, voluntary or involuntary attention. Thus, attention can be invoked as an important but nevertheless hypothetical construct to heuristically explain these various purported deficits. As long as structural anomalies cannot be specified as having a substantial relationship with a functional deficit, behavioral and physiological variables leave the construct and theories of attention unproven as a substantiated deficit in schizophrenia. Interdisciplinary research must provide clues for understanding the mechanisms of attention generally and how, if at all, they effect schizophrenic behavior.

A review of the literature of the past thirty years, does however, provide repeated examples of two behavioral tasks differentiating performances by schizophrenic patients and various other groups: the reaction time (RT) and continuous performance (CPT) tasks.

Reaction Time Studies

Shakow (1963) and his associates utilized a simple reaction time (RT) task in studying sustained attention, to demonstrate that chronic schizophrenics performed poorly as compared to normal subjects. The task employs simply a visual or auditory warning stimulus followed by a preparatory interval (PI) after which the auditory or visual target stimulus is introduced for the subject to respond to as quickly as possible. By varying the PI length (1-15 secs), the regularity of presentation of the various PI trials and modality of presentation, several results have been consistently reported: (1) overall slowness of performance of schizophrenics in RT, (2) inability of schizophrenics to take advantage of a consecutive set of similar PI trials past the 4th or 5th trial, (3) disproportionately impaired RT on shorter PI trials when in an irregular set of PI trials, particularly when followed by a longer previous preparatory interval (PPI), and (4) improved performance on a consecutive set of PI trials. Beyond a 4-6 second PI, a reversal occurs wherein schizophrenics perform better on an irregular set of long PI trials than on a consecutive set of trials with the same PI length. This has been termed the "cross-over effect" (Rodnick and Shakow, 1940). A "set index" was established from this crossover effect which differentiates chronic schizophrenic from normal performance, schizophrenic from other psychiatric subject performance, different states of ego disorganization and reactive from process schizophrenic performance (Rosenthal, Lawlor, Zahn and Shakow, 1960; Zahn, Carpenter and McGlashan, 1978). The reaction time task has been called the "common denominator" needed to separate schizophrenics from other pathological groups (Cromwell, 1978). Shakow (1963) explains the unique schizophrenic performance as a deficit in "major set" maintenance. Instead, the schizophrenic operates in isolated "segmental sets" or "minor sets" (Zahn et al., 1963; Zahn et al., 1961). For example, schizophrenic subjects are unable to take advantage of the regularity of PI trials over 6 seconds long. Furthermore, past the initial 4-5 trials, the schizophrenic subjects' RT performance lengthens to that of an irregular series of PI trials. Also, the schizophrenic patient has difficulty selecting relevant stimuli and ignoring irrelevant stimuli. Steffy and Galbraith (1973) calls these same phenomena "span of apprehension" defects and notes that there is a U-turn in performance over time due to a build up of cortical inhibitory process (Steffy and Galbraith, 1973). This temporally-linked performance disorder is found in children at risk, remitted schizophrenics and first degree relatives of schizophrenics and is viewed as a stable "vulnerability" characteristic (Cromwell, DeAmicis, Hayes and Briggs, 1979).

Salzinger's (1971) "immediacy hypothesis" similarly explains that schizophrenics can only be influenced by immediately prior stimuli and not by remote information. Evidence that supports this hypothesis illustrates that in a random PI series, if two similar PIs are given in a row, the second presentation of that PI is the best performance. These all appear to be outgrowths of the expectancy hypothesis stated previously (Deese, 1955).

Psychophysiological Findings in Schizophrenia

When correlating skin conductance and heart rate resting responses with RT performance, Zahn (1975) found a higher baseline level of arousal and a larger number of spontaneous responses to nonspecific stimuli in chronic schizophrenic patients who performed poorly on the RT task. Then, acute schizophrenics who improved clinically and had better RT scores were found to respond more to the environment than those who were not to clinically improve and had poor RT scores. The good responders had higher baseline level skin conductance measures and habituated faster to a skin conductance orienting stimulus and had greater HR deceleration during the task (Zahn, Carpenter and McGlashan, 1978).

Correspondingly, Venables (1977), utilizing an arousal theory, interprets these and similar psychophysiological findings as an indicator of faulty reticular activating system (ARAS) gating of stimuli. He finds a bimodal distribution of physiological responses. Those subjects who do orient electrodermally to nonsignal stimuli but are slow to habituate (poor premorbids) are identified as overaroused and those who do not orient (good premorbids) are identified as underaroused. Gruzelier (1978) found that a unitary state of arousal exists across cardiovascular, autonomic and somatic systems due to a limbic-forebrain imbalance. Two such unitary states, a high arousal state for chronic schizophrenics and a low arousal state for acute schizophrenics due to dysfunctional hippocampal-amygdaloid control, are found. When Chlorpromazine is administered the unitary state of arousal is dissolved and the three systems no longer work in parallel and respond differentially as is seen in normal subjects. The Chlorpromazine increases arousal in underaroused and decreases it for the overaroused (chronics). Venables and Gruzelier propose that due to this limbic dysfunction, temporal-limbic system involvement cause the display of symptoms found in these two types of schizophrenia. The cortex is unable to regulate responses to stimuli and therefore the distractibility of the acutely disturbed and the narrowed attention span of the chronic schizophrenic are seen.

The narrowed attention span in chronic schizophrenics is viewed as a reaction to the high arousal level of the three systems to keep out the flood of stimuli. Venables cites the Rodnick and Shakow "crossover effect" and Salzinger's "immediacy hypothesis" evidence as a result of narrowed attention span although no differential statement is made referring to the acutely disturbed.

Additionally, the chronics are found to be minimal scanners of the environment, have poor incidental learning and underestimate the size of the object in the size constancy task, an effect of underscanning. Acute schizophrenics correspondingly are found to perform in the opposite manner by Venables, McGhie, Calloway and Weckowicz (Venables, 1977; McGhie, 1977). Silverman (Nealeand Cromwell, 1977) finds the opposite results of Venables in the size constancy task, yet utilizes the same reasoning to explain his results. Neale and Cromwell (1977) show how the research for bimodal arousal levels in schizophrenics is contradictory, can be explained by various other constructs and utilizes poor discriminators to label process and reactive schizophrenia.

Schizophrenics do not have the expected decrease in reaction time found in the typical warning-preparatory interval-response stimulus paradigm although the alpha blocking occurs. This is seen as a dissociation between behavioral and electrophysiological indicators of arousal. Alpha rhythms have further been found to be less responsive to visual, intellectual and emotional stimuli. VEPs commonly increase in magnitude as the intensity of the stimulus increases. Schizophrenics do not respond or respond with decreases in VEPs to this same stimulus change. This is interpreted as poor attentiveness and orienting responses or alternately as due to high response variability seen in schizophrenics (Kooi, Tucker and Marshall, 1978).

Small CNV amplitudes in schizophrenics have been explained as a weak state of expectancy or a high baseline expectancy from which a large increase in expectancy is unattainable. Variability is also seen as contributory to these findings (Kooi, Tucker and Marshall, 1978).

Callaway and Jones (1975) recorded auditory evoked responses while subjects were told to ignore high and low tones that they heard. Normal, affective psychosis and character disordered subjects evoked similar responses for the two tones while schizophrenics had differential responses. It was interpreted in terms of significance given to the two tones by schizophrenics. Patients who improved with phenothiazines had improved AERs. Findings were alternately explained as due to the high response variability and/or low signal-to-noise ratios found in schizophrenics.

Continuous Performance Test

The continuous performance test (CPT) has been utilized as a measure of sustained attention (Garmezy, 1978). This task consists of brief serial visual or auditory presentation of simple stimuli from which the subject must detect the critical stimulus and respond as quickly as possible by pressing a key. Several conclusions concerning performance on this task have been repeatedly found (Garmezy, 1978):

(1) approximately 40-45% of chronic schizophrenic patients show performance deficits on this task, (2) a distraction magnifies the deficits in performance, (3) phenothiazine medication improves the performance of the schizophrenic although not to the level of normals (Mirsky and Kornetsky, 1978), (4) poor performers have significantly more relatives with mental illness and (5) poor reaction time performance on PPIs greater than four seconds, and (6) increased amounts of fast EEG activity and lack of slow wave sleep characterize those schizophrenic subjects who perform poorly on the CPT (Kornetsky and Orzack, 1978). These investigators assert that schizophrenics have a core deficit in attention due a central nonspecific hyperarousal and a phasic hypoarousal, which allows internal and external irrelevant stimuli to interfere with registration of critical stimuli. The poor CPT performance is additionally found in remitted patients (Venables, 1977) and children at high risk for schizophrenia (Erlenmeyer-Kimling and Cornblatt, 1978), and does not correlate highly with cognitive task performance, diagnosis, ethnic background, marital status or birth order and is found to be an enduring trait (Kornetsky and Orzack, 1978).

To support their position, Mirksy and Kornetsky (1972) has used the CPT to test brain damaged patients and found that performance on this task is vulnerable to damage in the midbrain centers assumed to mediate arousal. Further support was evidenced by Mirsky and Kornetsky when they compared digit symbol and CPT performance and found Chlorpromazine, a drug affecting the midbrain reticular activating system, to directly affect CPT performance and not digit symbol (Mirsky and Kornetsky, 1972; Kornetsky and Orzack, 1964). Spohn, Lacoussiere, Thompson and Coyne (1978) correlated CPT, RT and physiological measures with and without the effect of Chlorpromazine and found chronic schizophrenics to have improved performance of the CPT and RT tasks as skin conductance responses decreased; and amplitude of heartrate decelerated and the amplitude of skin conductance responses decreased over time with Chlorpromazine administration.

Therefore, several research lines of evidence point to a central, enduring attentional deficit implicating subcortical-cortical connections. The RT and CPT appear to be two tasks which tap an enduring dysfunction which is found in their first degree relatives, including children at high risk for schizophrenia (MacCrimmon, Cleghorn, Asarnow, and Steffy, 1980).

Hemispheric Functioning in Schizophrenics

A volume of evidence has been growing presenting schizophrenics as having abnormal structural, behavioral and psychophysiological hemispheric functioning. Arguments have been presented (Wexler, 1980) for left or interhemispheric abnormalities.

Recent studies (Pincus and Tucker, 1978) find a high 60 to 70 percent of soft, nonlocalizing abnormal neurological signs in schizophrenics. Included are astereognosis, coordination defects, abnormal EEG's, cortical sensory abnormalities and speech defects among the fifteen kinds noted. This high incidence is viewed as in some way connected with the "schizophrenic" disease and not as coincidental.

The study of living brain tissue by computerized tomography (CT scan) has lent further evidence of structural brain abnormalities in schizophrenics. Recent studies by Weinberger (1979) and Johnstone, Crow, Frith, Husband and Kreel (1976) have found chronic schizophrenics to have significantly greater cerebral ventricular size than normal controls. Additionally, Heath, Franklin, and Shraberg (1979) and collaborators have found a number of functionally diagnosed schizophrenics to have significant atrophy of cerebellar vermis, as Weinberger found, even though neurological examinations were negative.

One recent study presented evidence of inverted frontal lobe width asymmetries in schizophrenics basedon linear measurements made on CT scans (Luchins, Weinberger and Wyatt, 1979).

Using regional blood flow techniques, Franzen and Ingvar (1975) have found that the distribution of blood flow in schizophrenics is high in post central regions and comparatively low in left frontal regions. They attribute the lack of goal directed behavior, lack of initiative, ambivalence, indifference, etc. to the hypofrontal blood flow and the sensory-mismessages or hallucinations to the increased post central sulcus blood flow. They attribute the dysfunction to a defective "nonspecific mediothalamic fronto-cortical projection system" which has an activating effect on frontal and an inhibitory effect on post central afferent impulses. Although a left hemispheric dysfunction is suggested, no right hemispheric information is obtained.

The link beteween behavior and anatomy is based in part on evidence that when tasks presenting faces and spatial material are presented to the left visual half-field, they are more quickly and accurately performed than when presented to the right visual half-field (Gazzaniga, 1970; Dimond and Beaumont, 1974; Geffen, Bradshaw and Nettleton, 1972). Correspondingly, when words, trigrams or letters are presented to the right visual half-field, the material is responded to more accurately and quickly than if presented to the left visual half field (Dimond and Beaumont, 1974; and Kimura, 1966). Each hemisphere has been found to specialize in processing specific material. The left hemisphere processes verbal material and the right hemisphere processes nonverbal material most efficiently. The specialized processing has also been referred to as an analytical and a Gestalt approach. Perceptual asymmetries occur with performance on material specific tasks when both visual fields are separately exposed to the material. The stimulus information is theorized as traveling to the hemisphere which will most efficiently process the material. Verbal information will travel directly to the left hemisphere from the right visual field or indirectly over inter-hemispheric pathways from the left visual field (Kimura, 1966). The opposite is true of nonverbal material. The difference in performance is interpreted as due to delay (35 msecs.) and decay of information traveling the longer, inter-hemispheric route (Filbey and Gazzaniga, 1969; Moscovitch and Catlin, 1970). This asymmetrical functioning has been established in normals (Fontenot and Benton, 1972; Kinsbourne, 1970), those with brain damage (Milner, 1971) and those with no corpus collosum (Gazzaniga, 1970).

Evidence of interhemispheric transfer dysfunction in schizophrenics has been provided by Beaumont and Dimond (1973). Subjects were asked to visually match letters, digits or shapes inter- and intra-hemispherically. Significantly wider corpus collosums in schizophrenics were linked to "a pathology of articulation" between the two hemispheres. Yet their evidence cannot rule out intrahemispheric dysfunction for they also found intrahemispheric mismatching for material in both hemispheres in schizophrenics. Flor-Henry (1976) has found left hemispheric dysfunction in schizophrenics and right hemispheric dysfunction in manic-depressive patients. EEG evidence concurrently endorsed a proposed (Flor-Henry, 1974) left fronto-temporal lobe abnormality in schizophrenic patients and a right fronto-temporal dysfunction proposed for affective illnesses. When Chlorpromazine was administered, a left hemispheric voltage increase was observed as seen with clinical improvement (Serafetinides, 1973). Utilizing visual evoked potentials, Roemer, Shagass, Straumanis and Amades (1972) found that the VEP wave form stability was lower in the left than the right hemisphere for schizophrenics as compared to nonpatients, nonpsychotics and psychotic depressives.

Although Kinsbourne (1970) supports the evidence for asymmetrical functioning of the hemispheres, he feels that direct contralateral and indirect ipsilateral pathways cannot account for the robust asymmetrical reaction time latency difference seen between the hemispheres. He feels a better explanation for the asymmetrical performance is one of an attentional nature. Each hemisphere serves the contralateral direction in space, therefore, when a hemisphere is in preparatory activation, attention is biased to the contralateral side. This gives an advantage for processing any material displayed in that area of space. Through expectancy set, material specific warning stimuli and/or central fixation, one hemisphere can be activated and attention biased to the contralateral side.

In accordance with this hypothesis, Gur (1978) found that in normal subjects leftward eye movements were elicited with spatial and/or emotional material and right gaze eye movements were elicited by verbal material. In contrast to normals, when schizophrenics were tested on verbal and spatial tachistoscopically presented material, a right hemisphere superiority of performance was found. Schizophrenics were found to have significantly more rightward gazing for verbal, spatial and/or emtoional material when eye movements were monitored (Gur, 1978). He concludes that schizophrenics have a left hemisphere dysfunction consisting of an overactivation. Furthermore, an increased incidence of left-sidedness as measured by laterality scores comprised of handedness, footedness and eye dominance was found in schizophrenics. This is interpreted as a right hemisphere preference due to left hemisphere dysfunction by Gur (1977). Schweitzer, Becker and Welsh (1978) has found similar eye movement results and also attributes results to left hemisphere overactivation, although results can be interpreted as a right hemisphere underactivation (Myslobodsky and Horesh, 1978).

As discussed previously, Gruzelier and Venables (1974) have found bimodal response distributions on skin conductance OR's for schizophrenics. Either no response was elicited to auditory stimuli or responses were elicited and were associated with increased spontaneous fluctuations, higher response amplitudes, faster recovery times and shorter latencies. This along with other, previously mentioned data, pointed to an arousal dysfunction. Additionally, when response amplitudes from the right and left arms were compared, amplitudes were nonexistent or lower on the left for schizophrenics and lower on the right side for depressive patients, whereas no asymmetries were found in normals. These results supported ipsilateral, left hemispheric dysfunction in schizophrenics, as Flor-Henry found.

Gruzelier and Hammond (1980) found controls and schizophrenics to have a right ear advantage to dichotically presented digits. No drug effects were found. When schizophrenics were divided into over- and underaroused as indexed by electrodermal orienting responses, overaroused schizophrenics had a significantly larger right ear preference than normals. Paranoid schizophrenics showed superior performance to nonparanoids. Furthermore, overaroused schizophrenics had particular difficulty in selectively attending to left ear digits when right ear digits were 20 dBs louder, particularly when on phenothiazines. This was accounted for as a dysfunction of "left hemisphere inhibitory mechanisms." Controls obtained the opposite results, i.e. poor attending to right ear digits with louder left ear presentations. Underaroused schizophrenics had these difficulties bilaterally. Lateralized serial order differences for memory of digits were interpreted as information processing difficulties in schizophrenics, particularly overaroused schizophrenics. Dysfunctional left hemisphere processing is again indicated. Interestingly, they offer possible left hemisphere difficulties as due to lateralized phentothiazine effects in combination with intense stimuli.

Together these results provide substantial evidence of a left hemispheric dysfunction. Gruzelier (1978, p. 182) postulates that "a loss of left-sided hippocampal inhibitory influences may lead to excessive right hemisphere interference on left hemisphere processing via the hippocampal commissures." This compounded with a left sided "vulnerability" to inhibition and fatigue would result in deficited left hemisphere performance and increased right hemisphere performance on verbal tasks, since it is now known that the right hemisphere has basic verbal processing abilities (Gazzaniga, 1970) which are usually inhibited for preferential verbal processing to be carried out on the left. This imbalance is viewed as biochemical due to improvement in performance (Gruzelier, 1978; McGhie, 1977; Serafetinides, 1973) or a shift in performance with major tranquilizers (Gruzelier and Hamond, 1980).

Based on evidence that neglect is most often found in patients with lesions in the right parietal lobe and not infrequently with lesions in the right frontal lobe (Heilman and Valenstein, 1972), Heilman first proposed that unilateral neglect was a dysfunction of hemi-attention due to a disconnection in cortical-limbic-reticular activating pathways intricately linking parietal with brainstem mechanisms on the nondominant side. In support of this, cingulectomies were conducted to sever a corticolimbic pathway to produce neglect in monkeys (Watson, Heilman, Cauthen, and King, 1973). Further evidence was obtained from normals (Heilman and Van Den Abell, 1979; Heilman and Van Den Abell, 1980) supporting right hemispheric dominance for mediation of activation and intention. They found that while the left hemisphere can mediate its own activation by stimuli presented in the right visual half-field, the right hemisphere can effectively mediate activation for either hemisphere through stimuli presented to the left visual half-field. Reaction times were reduced by warning stimulus presentations in the left visual half-field more than when warning stimuli were presented in the right visual half-field. This supports data (Jeeves and Dixon, 1970) showing faster reaction times for stimuli presented in the left visual half-field than for stimuli presented on the right visual half-field. Heilman and Van Den Abell (1979) further found that warning stimuli presented in the left visual half-field reduced right hand reaction times more than warning stimuli presented to the right visual half-field. Left visual half-field warning stimuli reduced reaction times for the right hand more than right visual half-field warning stimuli reduced left hand RTS. Neglect seen most often with lesions occurring in the right hemisphere is explained by these findings. They postulate that with a left hemisphere lesion, the right hemisphere can mediate activation for the left hemisphere more effectively than the left hemisphere can mediate right hemisphere activation when the right hemisphere is lesioned. They further propose that the left hemisphere would also show decreased arousal due to a right hemisphere lesion.

Utilizing the accumulative evidence of right hemisphere dominance for arousal, Mesulam and Geschwind (1978) hypothesize a neocortical-limbic disconnection syndrome to account for schizophrenic attentional deficits. The nucleus accumbens septi, receiving input from both the hippocampus and amygdala and limbic midbrain dopaminergic projections, is thought to be the most likely place of chemical or structural disconnection.

Therefore, both the left and right hemispheres have been strongly implicated as the focus of disturbance in schizophrenia. Additionally, physiologically and functionally exemplified attentional dysfunctions have been reliably documented in schizophrenics and their relatives.

Although peripheral physiological evidence (i.e. skin conductance and eye movements) suggest an attentional dysfunction, no direct functional hemispherically mediated attentional deficits have been reliably produced (Wexler, 1980).

Upon close examination of the hemispheric studies conducted, some general methodological problems are apparent. Schizophrenic subjects were lumped together, examining acutely and chronically disturbed schizophrenics alike. Further, no provisions were taken to covary the effects of medication; and alcohol or illegal drug usage was not discussed. One further problem with the hemispheric studies in their use of cognitive and perceptual tasks rather than more direct measures of attention.

Specific problems of biased data interpretation plague this area of research. 1) Ingvar claims a left hemisphere dysfunction but does not look at the right hemisphere in the cerebral blood flow studies. 2) Gur's hypotheses are confounded with several intuitive problems as well as the general methodological problems noted above: a) although there is a higher left-handed incidence in schizophrenics, other groups such as graduate students have an inflated left-handed incidence, with no known pathology; b) utilizing Kinsbourne's hypotheses of expectancy, mode of response, and central fixation biasing material specific hemispheric processing, he has subjects verbalize their responses and uses a digit for fixation in both verbal and visuospatial tachistoscopic tasks, confounding results, as in the lateral eye gaze tasks. 3) Dimond and Beaumont find inter- and intrahemispheric dysfunctions but do not interpret the intrahemispheric data at all. 4) Gruzelier and Venables' attentional asymmetries are only demonstrated on peripheral psychophysiological measures, which do not correlate well with CNS measures many times. Further, Roemer, Shagass, Straumanis, and Amades (1972), using VEP's in a well conceived study finding left hemispheric dysfunction, did not look for attentional deficits.

Rationale

As the previous review suggests, there are a number of methodological and theoretical weaknesses in the literature concerning attentional dysfunction in schizophrenics. It is clear, though, that many chronic schizophrenics have an inability to "maintain set" or respond according to an "immediacy hypothesis" (Garmezy, 1978). This can be simply called an inability to maintain "a readiness to respond." Additionally, hemisphere information processes appear to be dysfunctional (Wexler, 1980). Gruzelier (1978) has proposed asymmetrical arousal dysfunction in schizophrenics based on skin conductance and heart rate measures.

Dominance for mediation of activation and intention or "a readiness to respond" has been evidenced through electrocortical (Heilman and Van Den Abell, 1980) recordings as well as behaviorally (Heilman and Van Den Abell, 1979). If the concept of hemisphere dominance for activation and intention is valid, the next logical step in schizophrenic research is to investigate the combination of these variables shown in isolation to be a problem, i.e. investigation of hemisphere intentional processes. A more precise understanding of the type of attentional dysfunction in schizophrenics is possible. Therefore, a well controlled study investigating hemisphere mediation of intention in schizophrenics would be useful in clarifying further the type of dysfunction seen in chronic schizophrenics. This, in turn, will further the progress in investigation of the etiology of this disease.

The object of the present paper is to 1) to replicate the proposed right sided dominance for visual intention in support of Heilman's theory; 2) to examine whether a dysfunction in intentional abilities in one or the other hemisphere is presented in many chronic schizophrenics; and 3) ascertain whether the expected deficit is a stable characteristic, i.e. whether this deficit is apparent when the subject is stabilized on medication.

A study is proposed in which a group of twenty chronic schizophrenics and twenty controls will be administered the reaction time task, as described by Rodnick and Shakow (1940). One verbal continuous performance task as explained by Kornetsky and Orzack (1978) and one nonverbal continuous performance task as described by Heilman (personal communication) will also be performed by all subjects. These tasks will be utilized to differentiate schizophrenics with intentional or "readiness to respond" deficits. Two additional tasks utilizing a visual half-field reaction time paradigm will be implemented. Stimuli will be neutral in one task and somewhat more verbally oriented in the second task. The first task will be used to tap hemisphere dominance for mediation of intentional abilities, while the second is to tap more analytical, left hemisphere material-specific intentional abilities. Controls will be compared to schizophrenics on these tasks before and after the deficited schizophrenics are singled out. Levels of medication dosage will be monitored at the time of task performance to covary for this independent variable if necessary (Held, Cromwell, Frank and Fann, 1970).

The specific hypotheses include:

I. a) Normal controls will have lower set indexes and fewer errors of omission and commission on the continuous performance tasks than patients with an attentional deficit. Schizophrenic patients with no attentional deficits will perform similarly to controls.

   b) Controls will have faster reaction times with the right hand than the left and faster reaction times to non-localizing material presented to the left visual half-field than the right visual half-field. The order of reaction times from fastest to slowest on stimuli presented to visual half fields should be: 1) left visual field--right hand; 2) left visual field--left hand; 3) right visual field--right hand; and 4) right visual field--left hand (Jeeves and Dixon, 1970).

   c) Controls will perform faster with the right hand than the left hand but will shift to faster right visual field reaction time presentations on material specific stimuli requiring left hemisphere activation.

II. Schizophrenic patients who perform significantly poorer on the simple reaction time set index and CPT tasks will perform differently on the half field tasks from controls: a) if there is a left hemisphere mediated intentional dysfunction, reaction times will be faster with verbal material presented in the left visual half-field as in the nonmaterial specific visual half-field task, which is predicted. b) If the right hemisphere mediated intentional processes are dysfunctional, lowering attentional abilities overall, both tasks will be performed more efficiently with material presented to the right visual half-field. If the schizophrenics are left as a single group, they will appear to look like the deficited schizophrenics.

CHAPTER TWO
METHOD

Subjects

Twenty right-handed chronic schizophrenics and twenty normal right-handed male subjects between the ages of 18 and 35 were utilized. All subjects were screened for alcohol or street drug usage and head trauma. Those with significant drug histories or head trauma were excluded. As part of a larger research protocol, all subjects received CT scans in screening for brain dysfunction and were determined to have normal scans by a neuroradiologist. Normals were selected from the Gainesville area through word of mouth. The diagnosis of chronic schizophrenia was determined by an experienced psychiatrist and the present investigator using DSM III criteria. All subjects were administered a full scale Wechsler Adult Intelligence Scale (WAIS) (Wechsler, 1958). Patient diagnoses include nine chronic schizophrenia, undifferentiated type, one chronic schizophrenia, undifferentiated type with schizoaffective components, one chronic schizophrenia, catatonic type, one chronic schizophrenia, disorganized type and eight chronic schizophrenia, paranoid type. Patients were tested only after stabilized on medication and the disorder described as being in remission by the attending psychiatrist and nursing staff. All patients were chosen from inpatient and out-patient populations of the Gainesville VA Medical Center. Hand dominance was determined by self report, finger tapping and hand dynamometer performance. Subjects were included if self report and at least one of her measure showed a right hand dominance.

Procedure

Five tasks, randomly ordered, were presented on an Apple II computer T.V. screen. Reaction times were monitored by the computer to the nearest one-tenth millisecond. The subject was comfortably seated 33 inches from the screen and his head placed in a chin rest for the tasks. Each subject performed the series of tasks once with the appropriate hands. All subjects completed all tasks. The controls were paid $50 for completing these and other tasks associated with another project.

Directions for tasks were read to the subject preceding each task. Subjects were encouraged to respond as quickly as possible to target stimuli and were discouraged from speaking during testing. The nonverbal CPT needed additional instruction, described in the following text.

Task #1

The simple RT task was administered to detect those schizophrenics with intentional deficits. The subject was instructed to view five sets of 26 RT trials as described by Zahn (1975). In the first three blocks, five different preparatory intervals (PIs) of 1, 2, 4, 7 and 15 seconds were presented in a predetermined quasi-random order. Each PI followed itself and every other PI one time. The last two blocks of trials contained 13 consecutive trials of 2, 4, 7 and 15 second PIs.

A white light, the warning stimulus, was presented for .5 seconds which the PI followed. The subject's job was to press the telegraph key with his right hand to the onset of the red light. If the response stimulus, the red light, was not responded to, it remained on for 1.5 seconds. The intertrial interval, within which time the subject could not respond, lasted four seconds.

The three blocks of trials contained three different quasi-random PI orders. The task lasted for 25 minutes. The subjects were then given a ten minute break within which they were encouraged to move around.

A set index was obtained for each subject and used as one criterion for determining those with intentional deficits. The following formula was used:

$$\text{SET INDEX} = \tfrac{1}{2} \left(\frac{M_{7.0R}}{M_{7.0I}} + \frac{M_{1.5R}}{M_{1.5I}} \right) M_H$$

$M_{7.0R}$ = mean of seven second PIs in the regular series.

$M_{7.0I}$ = mean of seven second PIs in the irregular series.

M_H = mean of highest PI reaction time.

Task #2 and #3

The CPT tasks were also used as indicators of intentional dysfunction. The subjects performed two CPT tasks, randomized among the other tasks independently, but described here together for convenience. One task, as described by Kornetsky (1978), consisted of a computer-randomized sequence of six letters, presented at a constant rate (1 per second) at a brief exposure time (.1 sec.). The subject's task was to press the key as quickly as possible with his right hand when the target letter (X) appeared but not when any of the other stimuli appeared (T, L, 0, A, F). This task lasted for ten minutes after which a 5 minute break was given.

The line orientation continuous performance task consisted of a computer-randomized sequence of six angles, together subtending a 90° angle. It was adapted to conform to the same procedure and presentation rate as the verbal CPT from procedures used by Benton (1975) and Fontenot (1982) for assessing left visual half-field right hemisphere processes in normals and brain damaged patients. The subject was first shown the six angles and the target angle was pointed out. Then the subject was allowed to practice the task for approximately 30 seconds or until he responded correctly to three consecutive target stimuli. He was given feedback as to his hit rate, due to the difficulty of the task. The task was then presented with no further assistance. A five minute break followed. Each task contained enough trials so that 50 trials of the critical stimuli appear. Errors of commission and omission were obtained for each subject.

Task #4 and #5

The lateralized RT tasks were administered to determine which hemisphere is dominant for attention in the two groups on a neutral task, #4, and a verbal task, #5. The subject viewed a central white asterick (referred to as the center design) for .5 secs. after which the letter X appeared for .075 secs, 5° to the left or right of fixation, while the subject was instructed to continue to fixate at the center of the screen for best performance. The PIs were presented in a quasi-random order at .5, 1.0, 1.5 and 2.0 seconds long in a predetermined sequence of two blocks of 48 trials each. Stimuli appeared on the right one-half the time and the left one-half the time in a randomized sequence. The subject could respond up to 1.5 seconds after stimulus presentation. The ITI was four seconds long and the task lasted 12 minutes, after which a 10 minute break followed.

Task #5 followed the same procedure of presentation. The words "TIN" or "TON" appeared to either the left or right of fixation in a quasi-random sequence. The subject was asked to press the key as quickly as possible to only the "TON" stimulus. These words were chosen to have the same frequency count in adult texts (T = 220 per 3000 words) (Thorndike and Lorge, 1972), similar verbal association values (a = 1.00 for tin, a = .97 for ton) and similar scaled meaningfulness values (M' = 4.73 for tin, M' = 4.10 for ton) (Noble, Sutker and Jones, 1968).

All subjects performed each of these tasks once with his left hand and once with his right hand in a predetermined randomly distributed sequence of LRRL, RLLR, LRLR, or RLRL.

Reaction times were recorded to the nearest one-tenth millisecond by the Apple II computer.

Statistical Analysis

All analyses were run under the Statistical Analysis System (SAS) (Goodnight, 1979a, 1979b; Sall, 1979; Delong, 1979; Sarle, 1979) utilizing computer facilities at the North East Florida Regional Data Center. Data analysis packages used in this study included the ANOVA (Graybill, 1961), Student t-test (Steel and Torrie, 1960), discriminant analysis (Anderson, 1958), Pearson product-moment correlation (Sall, 1979) and Kolomogorov-Smirnov D-statistic (Stephens, 1974). Consultations were obtained with Randy Carter, Ph.D. through the department of Biostatistics.

CHAPTER THREE
RESULTS

Group Characteristics

The mean age for schizophrenics was 28.3. The control mean age was 26.9. The two groups did not differ in age ($t = -1.27$, $p = .21$) as measured by a t-statistic. The two groups did have significantly different IQs as measured by the WAIS ($t = 6.99$, $p \leqslant .0001$). The control mean IQ was 120.4 and the schizophrenic mean IQ was 97.8. Tapping scores were also different for the two groups. The right hand mean tapping score for a 10 second period was 54.4 for controls and 48.6 for schizophrenics. The means were significantly different ($t = 2.66$, $p = .01$). The left hand mean tapping scores were also significantly different ($t = 3.28$, $p = .02$). Mean scores were 49.5 for controls and 43.5 for schizophrenics. A right hand minus left hand analysis yielded no significant differences between groups ($t = -.15$, $p = .88$). Hand dynamometer scores were also significantly different for groups when comparing individual hands. The right hand mean dynamometer score was 49.4 kilograms for controls and 39.3 kilograms for schizophrenics ($t = 5.99$, $p \leqslant .0001$). The left hand mean scores for 44.9 kilograms for controls and 34.9 kilograms for schizophrenics. When right hand minus left hand scores were compared, groups were again found to be similar ($t = .1116$, $p = .91$). Mean scores yielded 4.5 kilograms for controls and 4.35 kilograms for schizophrenics. Therefore, IQs, individual finger tapping and hand dynamometer scores were significantly different for the two groups. The two groups did not differ in age. Neither the hand dynamometer nor the finger tapping right hand-left scores differed for groups. This is an important consideration due to the implementation of right vs. left hand reaction time analyses for groups on the visual half-field tasks.

Correction Factors

A Kolomogorov-Smirnov D-statistic (Stephens, 1974) was performed on all reaction time data to test for distribution normality. The data was found to be skewed and flat-topped (platykurtic). Therefore, each reaction time was transformed to its log base 10 equivalent and all analyses were performed on the transformed data (Winer, 1962). Analysis of variance graphs and tables are also expressed in this manner due to poor representational equivalency of mean reaction times to mean reaction time logarithms to the base 10.

To test whether reaction times were adversely affected in schizophrenics by medication dosage, each patient's major tranquilizer daily dosage was converted to the Chlorpromazine equivalent (Held, Cromwell, Frank and Fann, 1970). Table 1 illustrates drug dosage correlation results for the simple reaction time task (Task #1). Although other studies using normal subjects (Tecce, 1970) and disturbed children (Sprague, Barnes and Werry, 1970) found the tranquilizers to adversely effect reaction time and accuracy, research utilizing chronic schizophrenic patients found no significant phenothiazine effect

Table 1. Correlation of Medication Dosage in Chlorpromazine Units with Simple Reaction Time Data

VARIABLE	MEAN	STD. DEV.	MIN.	MAX.	CORRELATION COEFFICIENT
PI 1	532.65	138.67	365	825	.24
PI 2	515.50	134.77	328	817	.24
PI 4	495.30	129.56	309	860	.17
PI 7	489.85	117.52	311	796	.20
PI 15	526.75	149.62	332	905	.07
Set Index	749.10	266.21	341	1416	.09

Note: The reaction times are from the irregular series of preparatory interval trials of Task 1 measured in milliseconds.

(Held et al., 1970; Heilizer, 1959) or improved scores (Brooks and Weaver, 1961). Phenothiazines were found to adversely effect complex motor skills requiring coordination of both hands (Pearl, 1962). This study found no phenothiazine effects for simple reaction time. No covariance procedures were necessary due to the low correlations found which agrees with results in other studies using chronic schizophrenic subjects.

Task #4 Results:
Schizophrenics vs. Controls

A repeated measures design analysis of variance on mean reaction time scores revealed main effects for Group ($p \leqslant .0001$), visual half-field ($p \leqslant .0001$), Blocks ($p = .0031$) and Preparatory Interval ($p \leqslant .0001$) as shown in Table 2. The schizophrenics performed much more slowly than controls. Surprisingly, shortest reaction times were found for the two-second preparatory interval (PI), although these did not differ significantly from 1.5 PI reaction times. Both the 2.0 and 1.5 second PI reaction times were significantly faster than one second PI reaction times which, in turn, were significantly faster than 0.5 second PI reaction times as revealed by a post hoc Duncan's Multiple Range Test.

The main effect for Block was due to an increase in reaction time over blocks of trials. The task lasted 12 minutes. This increase appears in the last six minutes. When a post hoc analysis of variance was performed on the Group X Block interaction, no block effect was found for controls ($F = 1.14$, $p = .2986$) but a significant block effect

Table 2. Repeated Measures Design ANOVA Table for Visual Half-Field Task 4 (Neutral Stimuli) for Controls and Schizophrenics: Significant Results

SOURCE	DF	SUM OF SQUARES	F VALUE	PROB.>F
Model	1165	41.55	21.36	.0001
Error	114	.19		STD. DEV.
Corrected Total	1279	41.79		.041

SOURCE	DF	ANOVA SS	F VALUE	PROB.>F
*Group	1	17.56	35.40	.0001
VHF	1	.10	30.42	.0001
Block	1	.10	9.98	.0031
PI	3	.99	77.78	.0001
Group X VHF	1	.02	6.03	.02
Group X Block	1	.04	3.98	.05
VHF X PI	3	.03	3.64	.01
VHF X Block X PI	3	.02	2.94	.04

---

* For tests of hypotheses the ANOVA MS for subj x variable (group) is used as an error term to account for subject within group variability.

was found for schizophrenics (F = 9.45, p = .0062). This interaction effect is illustrated clearly in Figure 1.

The main visual half-field (VHF) effect was found to be due to faster reaction times for the left visual half-field overall. A post hoc ANOVA holding group constant for the Group X VHF interaction revealed a significant left visual half-field superiority for controls (F = 41.89, $p \leqslant .0001$). The left visual half-field superiority approached significance for schizophrenics (F = 3.77, p = .0672). This interaction is illustrated in Figure 2.

A post hoc analysis of variance holding preparatory intervals constant was performed on the VHF X Block X PI interaction. Figure 3 illustrates the effects discussed. The .05 PI showed a main effect for blocks of trials (F = 40.73, $p \leqslant .0001$) and visual half-field (F = 11.684, $p \leqslant .0001$) revealing both a left visual half-field RT superiority and an increase in reaction time over blocks of trials. The one second preparatory interval had similar effects for VHF (F = 4.42, p = .0491) and blocks of trials (F = 12.69, p = .0021). The 1.5 second PI reaction times had no VHF effect but did increase over blocks of trials (F = 15.16, p = .0010). This also accounts for the significant VHF X PI effect found in Table 2. Lastly, the two second PI reaction times showed a main effect for a left visual half-field superiority (F = 6.88, p = .0168) but no increase in RT over blocks.

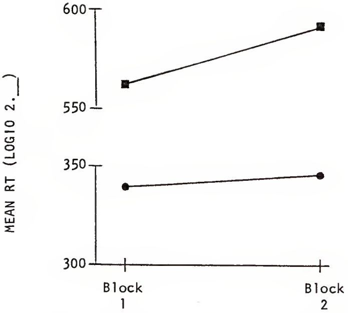


Figure 1. GROUP X BLOCK Interaction: Visual Half-Field Task 4-- Neutral Stimuli

■ Schizophrenics

● Controls

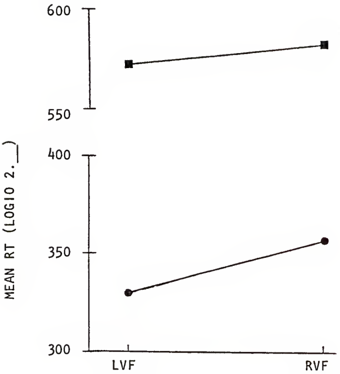


Figure 2. VHF X GROUP Interaction: Visual Half-Field Task 4--Neutral Stimuli

■ Schizophrenics

● Controls

Figure 3. BLOCK X VHF X PI Interaction: Visual Half-Field Task 4--Neutral Stimuli.

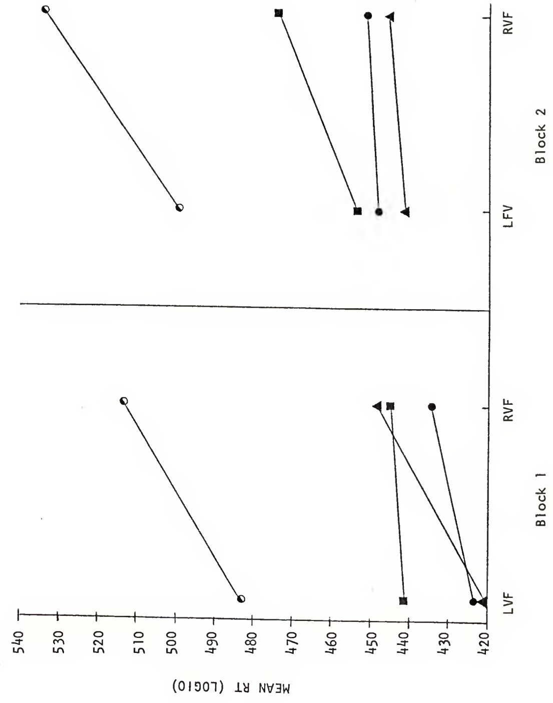
Preparatory Interval

● 1.5 secs

▲ 2.0 secs

■ 1.0 secs

⊘ .5 secs


MEAN RT (LOG10)
540
530
520
510
500
490
480
470
460
450
440
430
420
LVF
RVF
Block 1
LFV
RVF
Block 2

Division of Schizophrenics into Two Groups: Attention Deficited and Non-Attention Deficited

The set index was calculated for each subject as indicated in the procedure section. The distribution of scores in Figure 4 illustrates the two distributions. Four schizophrenics overlapped the control distribution. These results parallel those found by Rodnick and Shakow (1940). Both misses and false alarms were added together to create the scores for each of the continuous performance tasks. Using these three measures a discriminant analysis was performed (Anderson, 1958). Table 3 shows the posterior probability of group membership. The five schizophrenics who did not have 1.000 probability in the schizophrenic group consisted of four chronic paranoid schizophrenics and one chronic undifferentiated with schizo-affective components. The four selected to be in the nonattentionally deficited group consisted of one chronic undifferentiated with schizo-affective components and three chronic paranoid schizophrenics. These four are the same four that overlapped the control distribution of set indexes. These four schizophrenics were the nonattentionally deficited group used in both Task #4 and Task #5 analyses.

Further analyses were performed on these three tasks. T-tests (Steel and Torrie, 1960) indicated that schizophrenic and control groups obtained significantly different means on all three tests. The schizophrenic group had significantly more errors ($\overline{X} = 3.63$) than the control group ($\overline{X} = .41$) on the verbal CPT ($t = 3.61$, $p = .0009$). On the nonverbal CPT, the mean number of errors for the schizophrenic group ($\overline{X} = 9.84$) was significantly larger than the mean number of errors for the control

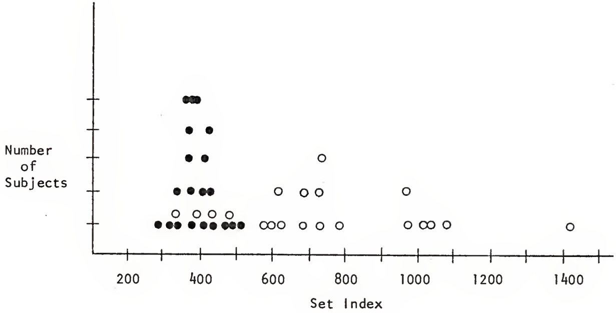


Figure 4. Set Index.

Table 3. Discriminant Analysis Reclassification of Schizophrenics into Non-Attentionally Deficited and Attentionally Deficited Groups Utilizing the Set Index, Verbal CPT and NonVerbal CPT

Subject	From Group	Classified into Group	Posterior Probability of Membership in Group C	S
0302	C	C	.9946	.0054
0710	C	C	.9985	.0015
1837	C	C	.9932	.0068
2080	C	C	.0067	.0033
2725	C	C	.9305	.0695
3322	C	C	.9979	.0021
3377	C	C	.9982	.0018
3428	C	C	.9918	.0082
4140	C	C	.9976	.0024
4216	C	C	.9955	.0045
4550	C	S	.4980	.5020
4660	C	C	.9989	.0011
4686	C	C	.9946	.0054
6045	C	C	.9990	.0010
6585	C	C	.9291	.0709
6850	C	C	.9878	.0122

Table 3. (Continued)

7104	C	C	.9974	.0026
8225	C	C	.9977	.0023
9022	C	C	.9916	.0084
9740	C	C	.9477	.0523
0417	S	S	.0000	1.0000
0513	S	S	.0000	1.0000
0516	S	S	.0000	1.0000
* 1326	S	S	.2643	.7357
1910	S	S	.0000	1.0000
2294	S	S	.0000	1.0000
* 3033	S	S	.1813	.8187
* 3214	S	C	.5702	.4298
3240	S	S	.0000	1.0000
5467	S	S	.0000	1.0000
* 6244	S	C	.9362	.0638
6443	S	S	.0000	1.0000
7139	S	S	.0000	1.0000
7989	S	S	.0000	1.0000
8256	S	S	.0000	1.0000

Table 3. (Continued)

8299	S	S	.0117	.9883
9229	S	S	.0000	1.0000
9305	S	S	.0000	1.0000
9594	S	S	.0000	1.0000
9769	S	S	.0000	1.0000

---

* Reclassified schizophrenics into non-attentionally deficited group on the basis of p>.1000 for membership in control group.

group ($\overline{X} = 6.75$) ($t = -6.48$, $p \leqslant .0001$). Similarly, the mean set index for the schizophrenic group ($\overline{X} = 749$) was significantly higher than the mean set index for the controls ($\overline{X} = 399$) ($t = -5.76$, $p \leqslant .0001$).

When a discriminant analysis (Anderson, 1958) was performed on each task for the schizophrenic group and the control group, ten schizophrenics were reclassified into the control group on the verbal CPT, three schizophrenics were reclassified on the nonverbal CPT and three schizophrenics were reclassified on the set index. Therefore, the nonverbal CPT and the set index test differentiated between the schizophrenic group and the control group. When comparing discriminant analysis reclassifications of schizophrenics into the control group on individual tasks to discriminant analysis reclassifications from the combination of three tasks (Table 3), the set index reclassifications most closely compares to Table 3. The verbal CPT included all four schizophrenics chosen on Table 3 plus six additional individuals. The nonverbal CPT had only one schizophrenic individual in common with the combined discriminant analysis (Table 3). The set index had three reclassified individuals out of the four chosen on Table 3.

Task #4 Results: Controls vs. Attentionally Deficited Schizophrenics vs. Non-Attentionally Deficited Schizophrenics

A repeated measures design analysis of variance on mean RT scores for three groups obtained main effects for Group ($p \leqslant .0001$), Visual

Half-Field ($p \leqslant .0001$), Block ($p = .0035$) and PI ($p \leqslant .0001$) as shown in Table 4. Results not involved with the newly formed Group variable are unchanged and will not be repeated. The post hoc Duncan Multiple Range Test for Group indicated that control group reaction time scores differed significantly from attentionally deficited schizophrenic group scores but neither differed from the non-attentionally deficited group.

The Group X VHF interaction is illustrated in Figure 5. In a post hoc ANOVA holding group constant, a significant left visual half-field effect was found for the control group ($F = 41.89$, $p \leqslant .0001$) but no significant half-field effect was found for either the non-attentionally deficited ($F = 1.83$, $p = .2689$) or the attentionally deficited group ($F = 2.13$, $p = .1650$).

The Group X Hand X Block interaction is illustrated in Figure 6. A post hoc ANOVA holding Block constant revealed a Group X Hand interaction for Block 1. Further post hoc ANOVAs revealed that the controls had a superior right hand performance ($F = 6.56$, $p = .0191$) while neither the non-attentionally deficited ($F = 2.84$, $p = .1907$) nor the attentionally deficited ($F = .94$, $p = .3481$) groups had any hand preference. The appearance of a left hand superiority for the non-attentionally deficited group was due to subject variability, as seen by the resulting $p = .1907$. The subject (group) X hand denominator is used as the error term to correct for within group variability.

Holding hand constant in the post hoc ANOVA for Group X Hand X Block revealed a main effect for blocks for the right hand ($F = 10.34$, $p = .0027$). This demonstrated that over blocks of trials the right hand reaction time increased for all groups. For the left hand a

Table 4. Repeated Measures Design ANOVA Table for Visual Half-Field Task 4 for 3 Groups

SOURCE	DF	SUM OF SQUARES	F VALUE	PROB.>F
Model	1168	41.56	21.78	.0001
Error	111	.18		STD. DEV.
Corrected Total	1279	41.74		.04

SOURCE	DF	ANOVA SS	F VALUE	PROB.>F
*Group	2	19.31	20.90	.0001
VHF	1	.10	29.91	.0001
Block	1	.10	9.72	.0035
PI	3	.99	76.43	.0001
Group X VHF	2	.02	3.15	.05
Group X Hand X Block	2	.03	4.36	.02
VHF X PI	3	.03	3.59	.0160
Block X VHF X PI	3	.02	2.94	.0359

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* For tests of hypotheses the ANOVA MS for subj x variable (group) is used as an error term to account for subject within group variability.

Figure 5. GROUP X VHF Interaction: Visual Half-Field
Task 4--Neutral Stimuli

■ Attentionally Deficited
Schizophrenic

▲ Non-Attentionally Deficited
Schizophrenic

● Controls

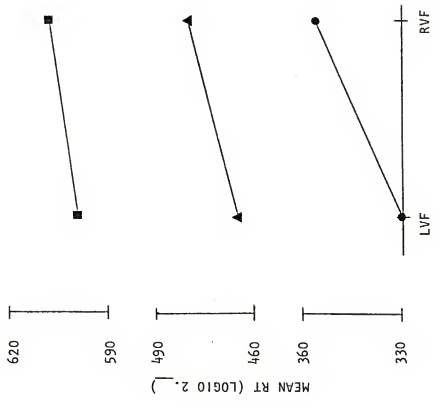
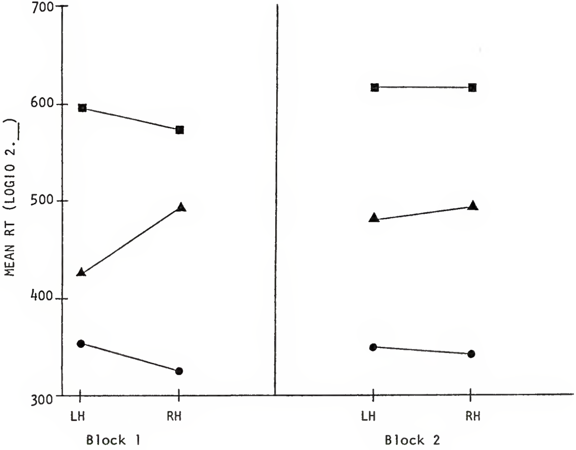

620
590
490
460
360
330
MEAN RT (LOG10 2._)
LVF
RVF

Figure 6. GROUP X HAND X BLOCK Interaction: Visual Half-Field Task 4--Neutral Stimuli

- ■ Attentionally Deficited Schizophrenic
- ▲ Non-Attentionally Deficited Schizophrenic
- ● Controls


700
600
500
400
300
MEAN RT (LOG10 2._)
LH
RH
Block 1
LH
RH
Block 2

Group X Block interaction was revealed. Further post hoc ANOVAs showed that only in the non-attentionally deficited group did the left hand RT increase over blocks of trials (F = 20.29, p = .0204). Neither the control group (F = .06, p = .8035) nor the attentionally deficited schizophrenics (F = 2.93, p = .1077) had significant increases in RT for the left hand over blocks of trials. Therefore, the right hand RT did not increase for controls or attentionally deficited schizophrenics. Yet there is a difference between the attentionally deficited schizophrenics and controls in this effect. Figure 6 illustrates that the left hand RTs decrease slightly for controls over time while they increase slightly over time for the attentionally deficited schizophrenics.

In the last post hoc Group X Hand X Block ANOVA, holding Group constant, a right hand superiority was found for controls (F = 4.32, p = .0513). No effect was found over blocks of trials (F = 1.14, p = .2986). No significant effects were found for the non-attentionally deficited schizophrenics although an increase over blocks of trials approached significance (F = 8.82, p = .0591). The attentionally deficited schizophrenics had no hand effect but showed an RT increment over blocks of trials (F = 6.34, p = .0237). Therefore, several significant effects were revealed in this complex three-way interaction. The controls showed a right hand superiority whereas neither schizophrenic group showed any hand preference. The attentionally deficited schizophrenic group had overall increased reaction times over blocks of trials and the non-attentionally deficited tended to have increased responses over time. Overall, right hand performance showed increased response times over blocks of trials. The left hand performance increased significantly over time for the non-attentionally deficited schizophrenics, tended to increase for the attentionally deficited schizophrenics and tended to decrease for the controls over time.

Task #5 Results:
Controls vs. Schizophrenics

A repeated measures design ANOVA was performed on the 32 mean RTs (HAND X PI X VHF X Block) for each individual. Those cells not containing RTs were given the maximum reaction time of 1500 msecs. This occurred 14 times for Block 1 and 19 times for Block 2. Main effects were found for Group (p = .0001), Block (p = .0070), and PI (p = .0048). The Group main effect was due to overall faster reaction times by controls as shown in Table 5. The Block main effect is accounted for by slower reaction times in the second block of trials. A post hoc Duncan's Multiple Range Test revealed fastest reaction times for the one second and two second preparatory intervals. These two had significantly faster RTs than the .5 and 1.5 second PIs.

A post hoc ANOVA for the VHF X PI interaction revealed a left visual half-field effect for reaction times at the .05 preparatory interval (F = 8.69, p = .0082) but no visual half-field effect at any other preparatory interval.

The post hoc ANOVA for the Block X PI interaction revealed no significant differences among the four PI mean reaction times (F = 1.57, p = .2060) for Block 1 but significantly greater mean RTs at the .05 and 1.5 second preparatory intervals than the 2.0 and 1.0 second intervals in Block 2 (F = 9.27, p = .0001) as analyzed by

Table 5. Repeated Measures Design ANOVA Table: Visual Half-Field Task 5 for 2 Groups

SOURCE	DF	SUM OF SQUARES	F VALUE	PROB.>F
Model	1165	20.97	4.16	.0001
Error	114	.49		STD. DEV.
Corrected Value	1279	21.46		.07

SOURCE	DF	ANOVA SS	F VALUE	PROB.>F
*Group	1	7.24	37.36	.0001
Block	1	.06	8.13	.0070
PI	3	.06	4.58	.0048
VHF X PI	3	.06	5.10	.0025
Block X PI	3	.05	4.18	.0076
Group X VHF X Hand X Block	1	.02	7.29	.0103

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* For tests of hypotheses the ANOVA MS for subj x variable (group) is used as an error term to account for subject within group variability.

a post hoc Duncan's. This significant increase in RT for PI .05 and 1.5 seconds over blocks of trials accounts for the overall slower reaction times at these intervals.

Figure 7 illustrates the Group X Block X Hand X VHF interaction. A post hoc ANOVA on this interaction revealed a left visual half-field superiority for the controls (F = 4.21, p = .0541). No visual half-field effect was found for the schizophrenics. Instead an increase over blocks of trials was found for the schizophrenics (F = 7.36, p = .0138). Additionally, a Block X VHF X Hand interaction (F = 6.93, p = .0164) was found for the schizophrenics. This was found to be due to increases in response times over blocks of trials for left visual half-field right hand (F = 6.41, p = .0203) and right visual half-field left hand (F = 15.53, p = .0009) performance. Although otherwise evenly distributed, nine of the 19 fill-in response times were for left visual field-right hand cells. Therefore, this increase in RT partly reflects an increase in incorrect rejections for left visual field-right hand presentations over time.

Task #5: Controls vs. Attentionally Deficited Schizophrenics vs. Non-Attentionally Deficited Schizophrenics

A repeated measures design ANOVA was performed on Task #5 with three groups on mean RT data. Table 6 shows the resulting significant effects. Main effects again include PI (p = .0050), Block (p = .0067) and Group ($p \leqslant .0001$). The group main effect was due to a significant difference between the performance by controls and schizophrenics as

Figure 7. GROUP X BLOCK X HAND X VHF Interaction: Visual Half-field Task 5 - Verbal Stimuli

■ Right Hand - Schizophrenic
⊡ Left Hand - Schizophrenic
● Right Hand - Control
⊙ Left Hand - Control

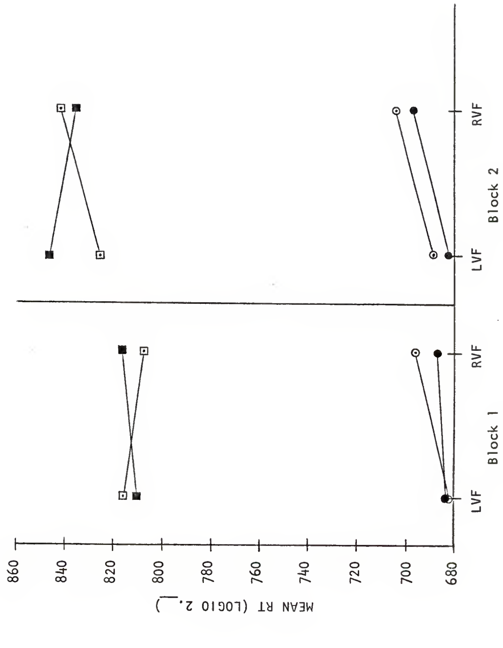
MEAN RT (LOG10 2._)
860
840
820
800
780
760
740
720
700
680
LVF
RVF
Block 1
LVF
RVF
Block 2

Table 6. Repeated Measures Design ANOVA Table: Visual Half-Field Task 5 for 3 Groups

SOURCE	DF	SUM OF SQUARES	F VALUE	PROB.>F
Model	1168	20.98	4.16	.0001
Error	111	.48		STD. DEV.
Corrected Total	1279	21.46		.07

SOURCE	DF	ANOVA SS	F VALUE	PROB.>F
*Group	2	7.48	19.42	.0001
Block	1	.06	8.24	.0067
PI	3	.06	4.55	.0050
VHF X PI	3	.06	5.04	.0027
Block X PI	3	.05	4.26	.0070
Group X VHF X Hand X Block	2	.03	5.03	.0117

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* For tests of hypotheses the ANOVA MS for subj x variable (group) is used as the error term to account for subject within group variability.

analyzed by a Duncan's Multiple Range Test. No significant difference was found between the attentionally and non-attentionally deficited schizophrenics in this main effect. Main and interaction effects not involving the variable Group will not be considered here since results are the same as those for Task #5: Two Groups.

The Group X Block X Hand X VHF interaction was further analyzed by post hoc ANOVAs. Figure 8 illustrates this interaction. The controls were found to have a left visual field effect (F = 4.21, p = .0541). No main or interaction effects were found for the non-attentionally deficited group.

The attentionally deficited group was found to have increased reaction times over blocks of trials (F = 9.34, p = .0080). An additional Block X VHF X Hand interaction (F = 9.34, p = .0080) was further analyzed and revealed increased reaction times for the right visual half-field (F = 13.08, p = .0025), the left visual half-field (F = 4.46, p = .0519) and the right hand (F = 4.50, p = .0509) over blocks of trials. Interestingly further analyses revealed that the left visual half-field right hand performance (F = 7.50, p = .0512) and the right visual half-field left hand performance (F = 8.90, p = .0093) both worsened over blocks of trials. Neither left visual half-field left hand or right visual half-field right hand performance experienced this increase in response time over blocks, as found in the two-group analyses. Again this partly reflects an inability over time to discriminate left visual field-right hand material within the amount of time given each individual to respond.

Figure 8. GROUP X BLOCK X UHF X HAND Interaction: Visual Half-Field Task 5 - Verbal Stimuli

■ Right Hand - Attentionally Deficited

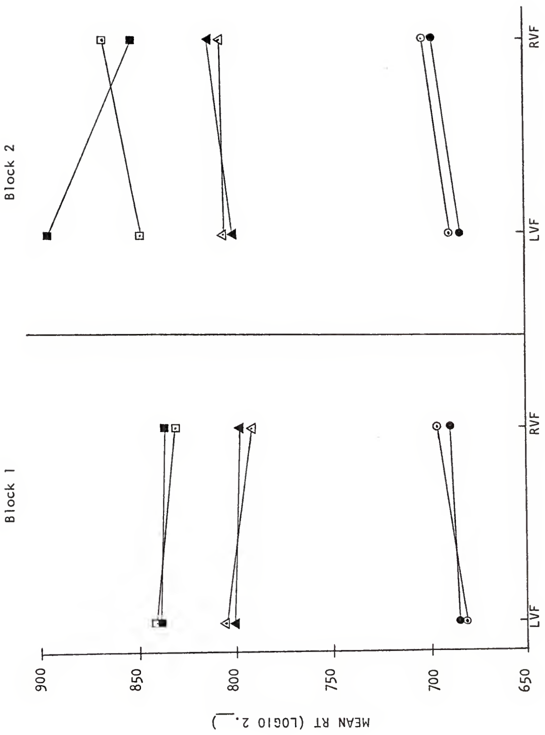
⊡ Left Hand - Attentionally Deficited

▲ Right Hand - Non-Attentionally Deficited

△ Left Hand - Non-Attentionally Deficited

● Right Hand - Controls

⊙ Left Hand - Controls


Block 1
Block 2
MEAN RT (LOG10 2._)
900
850
800
750
700
650
LVF
RVF
LVF
RVF

CHAPTER FOUR
DISCUSSION

Results indicated that as a group, schizophrenics performed much more slowly than controls in the visual half-field RT tasks as expected. Simple reaction time task results also reflected a large differential performance between controls and schizophrenics as reflected by the set index. Here the difference entails an inability to maintain a "set" for over five seconds or to profit from a regular series of preparatory intervals (Garmezy, 1978). These results were found not to be due to major tranquilizer medication, as others have also indicated using reaction time paradigms (Held et al., 1970; Heilizer, 1959).

The two CPT tasks also differentiated schizophrenics from controls. Results indicated that the simple RT task and the nonverbal CPT differentiated schizophrenics from controls better than the verbal CPT. This suggests that performance on nonverbal attentional tasks better differentiates schizophrenics from controls than performance on verbal attentional tasks. It can be concluded that a general lowering of activation was found for schizophrenics since schizophrenics performed worse than normals on all three tasks. Additionally, the right hemisphere appears more involved than the left.

Schizophrenics were also found, as predicted, to have a different pattern of response on the visual half-field tasks from controls.

Normals had faster responses with neutral material presented to the left visual half-field (Task #4). This replicates findings by Jeeves and Dixon (1970) and supports the theory offered by Heilman and Van Den Abell (1979) that the right hemisphere is dominant for mediating activation and intention. The order of half-field hand responses from fastest to slowest were 1) left visual half-field right hand; 2) left visual half-field left hand; 3) right visual half-field right hand; and 4) right visual half-field left hand. These parallel results found by both the above studies, although these four half-field hand differences were not significant in the current research. Schizophrenics, on the other hand, did not have a significant visual half-field superiority for neutral material presentations (Task #4). Additionally, they were found to have an increase in reaction time over blocks of trials. These results together suggest an arousal or intentional dysfunction mediated by the right hemisphere. If the right hemisphere mediation of arousal is interrupted, the overall level of arousal is lowered, the arousal level of the right hemisphere being particularly compromised. The schizophrenic half-field results of overall slower reaction times can be explained by the overall lowering of arousal. The lack of a half-field effect for schizophrenics can be explained by arousal deficits of the right hemisphere compromising superiority of processing in intentional tasks. This dysfunction appears to intensify, possibly due to fatigue, during a work period lasting over six minutes.

When schizophrenics were divided into attentionally and non-attentionally deficited groups, four schizophrenics were found to be "non-deficited." This group included one chronic schizophrenic with schizo-affective components and three chronic paranoid schizophrenics. When comparing the three groups, this non-deficited group was found to have faster overall responses than the deficited group although not significantly different from either the controls or the deficited group. Additionally, thenon-deficited group was found not to have any visual half-field differences in reaction time. In these respects they did not perform differently than the deficited schizophrenic group. Interestingly, with the creation of this third group, a Group X Hand X Block interaction emerged indicating that all groups were found to have increased right hand response times over blocks of trials. Controls had a right hand superiority in the first block which was lost in the second block of trials due to increased response trials. Left hand responses tended to improve for controls, tended to increase for the attentionally deficited schizophrenics and increased for the non-deficited group over blocks of trials.

Together, the results on Task #4 (neutral material visual half-field presentations) indicate that the pattern of responses by schizophrenics do differ from that seen in normals. An intentional hypothesis can further be applied with the following evidence. Dimond and Beaumont (1973) found that on a visual half-field vigilance task performed by normals, the left hemisphere showed superior performance to the right hemisphere but accuracy decreased sharply over time. This differed from the lower level but steady state performance of the right hemisphere. They hypothesized that two levels of vigilance were found. A higher performance yet exhaustible left hemisphere system was backed up by a lower level right hemisphere mechanism which was not exhaustible. After research involving split brain patients utilizing a similar experimental paradigm Dimond (1979) altered his theory stating that while the left hemisphere may be responsible for a selective attentional process, that right hemisphere mechanisms were solely responsible for sustained attention. He found that on visual, tactile and auditory tasks the left hemisphere had attentional gaps and therefore, missed significantly more signals than the right hemisphere. This is compatible with the normal data presented for hands on the neutral material half-field RT task (Task #4). The right hand reaction times increased over blocks of trials while the left hand performance remained the same over time. An intentional or maintained readiness-to-respond dysfunction could then be applied to the two schizophrenic groups who 1) did not have a left visual half-field superiority and 2) had increased response times for both hands. It is not clear why the non-attentionally deficited group had significant left hand response time increases while the attentionally deficited group had a tendency for increased left hand response times. Sampling effects could be responsible for the schizophrenic group differences, since the non-attentionally deficited group contains only four members. It is clear, though, that both groups do have intentional deficits, quite possibly of a different nature, although these differences can not possibly be sorted out without further experimentation using a larger sample of non-attentionally deficited schizophrenics.

An information processing deficit can also explain results of Task #4. Generally an information processing model assumes that briefly presented sensory information is registered into a precategorical or sensory storage which has a brief time limit. At this stage registration is based on purely sensory features for unbiased storage for later categorical processing (Klatzky, 1975). Visual information in iconic storage (Neisser, 1967) lasts approximately 100-200 msecs. Some of this information, selected or filtered in terms of higher categorical properties is encoded and stored serially in a short term storage (Braff and Sacuzzo, 1981; Moscovitch, 1977; Klatzky, 1975). Moscovitch finds through backward masking experimentation, that hemispheric processing asymmetries emerge only at the more abstract, categorical stages and not during processes utilizing sensory features or a stimulus set (Broadbent, 1970). He also finds that this requires at least 100 msecs. processing time. Braff and Sacuzzo (1981) and Braff (1981) implementing backward masking paradigms find that schizophrenics have both longer criticial stimulus input thresholds for recognition and slower information processing. The "stimulus threshold duration" is defined by Braff as the shortest amount of time necessary for a subject to recognize a briefly presented unmasked stimulus. This initial stimulus recognition represents the amount of time for iconic registration. Information processing is assessed through backward masking briefly presented stimuli. In this manner one can assess the amount of time necessary for information to be transferred from iconic storage to the more permanent short term storage. Information is said to be transferred at a certain rate, measured by how short the ITI can be without disturbing conscious recognition of the stimulus by the mask. This is indicative of the rate of categorical information processing. Since a longer amount of time is necessary for schizophrenics to process information than is available, a possible disruption or fragmentation of serial processing occurs, eventually leading to psychotic symptoms (Yates, 1966). While Braff found only chronic schizophrenics to have these two deficits, he found certain paranoid schizophrenics to not have the threshold duration dysfunction and only the information processing difficulty. These deficits are found not to be due to medication (Braff, 1981). Furthermore, Collins, Keitzman, Sutton and Shapiro (1978) found that these differences between schizophrenics and controls are not due to motivation. Using a four msec. stimulus and a six msec. double-pulse stimulus, the investigators found schizophrenics to make a reaction time "psychomotor discrimination" between the two stimuli at short six msec. durations which controls could not. Controls needed more than six msecs. to make the discrimination. Therefore, fragmentation can easily occur from temporally non-integrated information. Through this experiment, evidence was provided against an attentional deficit in schizophrenics. They suggest that if schizophrenics were poor attenders, they could not make this discrimination.

Jeeves and Dixon (1970) cited an experiment by Kerr, Mingay and Elithorn (1963) which found that visual stimuli (lights) presented closely in time received faster reaction times when presented to the right hemisphere than when presented to the left hemisphere. They proposed that stimuli were less likely to be grouped for recognition when presented in the right hemisphere than when presented in the left, suggesting faster processing of visual stimuli in the right hemisphere.

Together these results suggest an interpretation for Task #4 (neutral stimuli) data. Faster information processing occurs for controls than for chronic schizophrenics, thereby allowing for lateralization of functioning in controls but not for schizophrenics. A right hemisphere

RT superiority would emerge for controls due to faster material specific processing in the right hemisphere. This does not mean that a right hemispheric deficit in schizophrenics necessarily follows from this logic for initial iconic registration or slowed information processing may take too long for information to be adequately coded for further hemispheric processing before decay. Over time, with continued information being registered slowly, processing may continue to be further impaired, appearing as fatigue of these mechanisms. This would explain both the lack of asymmetrical processing and the increase in RT over blocks of trials found for the schizophrenic group.

Braff (1981) found that some chronic paranoid schizophrenics did not have an initial stimulus threshold duration deficit but had slowed information processing. In the present study three paranoid schizophrenics and one undifferentiated schizophrenic with schizo-affective symptoms were singled out by initial tasks as the non-attentionally deficited group. Half-field tasks provided evidence of partially less severe deficits than the 16 other schizophrenics. Only the left hand RT increase over blocks of trials was more severe in this group than the "attentionally deficited" group. The four schizophrenics labelled "non-attentionally deficited" had an insignificant increase in RT over blocks of trials as compared to the significant effect for the other patients. These four also had overall RTs which were not significantly different from the attentionally deficited group or significantly different from controls. How differences of information processing can account for these discrepancies would be difficult to say from this paradigm. In view of Braff's results, though, one can interpret

Task #4 results (neutral stimuli) in terms of information processing deficits. (1) The faster RTs by non-attentionally deficited schizophrenics were due to no initial threshold deficits, but slowed information processing was responsible for the lack of a half-field performance asymmetry. (2) A continuing breakdown of information processing was represented by a tendency for increased responses over time. (3) The attentionally deficited schizophrenics demonstrated an initial threshold deficit by the slow RTs. Slowed information processing was demonstrated by the lack of a half-field performance asymmetry and an increase in response times over blocks of trials.

Therefore, it is clear how deficits displayed by schizophrenics can be seen as a result of either attentional or information processing dysfunction, depending on the design of the experiment. One way of determining whether the dysfunction begins as a disturbance in activation and intention or at later processing stages would be to bilaterally record amplitudes of expectancy waves during the preparatory interval and the p-300 or late positive-going waves occurring 300-500 msecs. after the response stimulus. The expectancy wave or CNV is viewed as reflecting mechanisms of arousal and readiness to respond (Tecce, 1970; Luria and Homskaya, 1970), while the late component potential is commonly seen as reflecting information processing (Posner, 1978; Hink and Hillyard, 1978), both reviewed in previous sections. By concurrently recording reaction times and electrocortical activity at different stages, we can perhaps gain insight into the stage at which the disturbance begins. After this initial stage of dysfunction, all proceeding stages are most likely effected in some way, as Yates

(1966) claims. It is hypothesized here that the disturbance would be found at the level of a readiness to respond.

On the verbal discrimination half-field task, a main effect for preparatory interval indicated that one second and two second intervals had quickest responses. For Task #4 the fastest PI reaction times were for 1.5 and two second intervals. For both tasks the two second preparatory interval gleaned fastest reaction times. Lansing, Schwartz, and Lindsley (1959), Karlin (1959) and Heilman and Van Den Abell (1978) found foreperiods of .5 to one second long to best reduce reaction times. Teichner (1954) found fastest reaction times with foreperiods from 1.5 - 8.0 seconds long. Rodnick and Shakow (1940) also found this PI (2.0) to yield fastest reaction times. Therefore, the present results for PI most closely agrees with results by Shakow and Teichner.

The main effect for Blocks again indicated an increase in response times over blocks of trials. This is accounted for totally by the schizophrenic group. Schizophrenics were again found to respond much more slowly than normal controls on Task #5.

The only effect found for controls on the verbal half-field task (Task #5) was a left visual half-field superiority. This was somewhat surprising since the task was a word discrimination procedure. Two procedural comments are called for at this point. First, the words to be discriminated differed only by one letter. This is somewhat of a concrete discrimination and could most easily be made by a shape or light intensity discrimination. This would not require using any verbal labels and could more easily use precategorical processing (Moscovitch, 1977) or a visual figural mode. Precategorical processing would dictate that no half-field effect would occur. This leads one to conclude that a visual figural or stimulus set was utilized, which requires less processing time (Broadbent, 1971). The second procedural detail which could account for the same outcome would be the fast 75 msec. presentation time. It is possible that both these points accounted for the reversed asymmetry. The only piece of research which gives evidence against these arguments is a paper by Zenhausen and Parisi (1981). They presented pictures and words for discrimination in each of the visual half-fields. Again, reaction time was the response mode. Instead of a neutral warning stimulus they used digits to insure central fixation. They found an overall left visual half-field superiority which was erroneously attributed to the "nonverbal" digit used as a central fixation. Of course, digits are verbally encoded, yet their results, in spite of a verbal warning stimulus, still found a left field effect. No information was available on the details of the type of discrimination or presentation rate. Therefore, a simple experiment can be performed to investigate whether this left visual half-field effect is due to an inherent preference for left visual field-right hemisphere processing in reaction time tasks tapping readiness to respond or if it is due to the procedural details. One can present the two word discrimination task at a slower speed (125 msecs.) and present a more abstract verbal task used in other paradigms at a fast and slow rate. These combinations would be sure to weed out the processes involved.

While the controls evidenced a left visual half-field effect, none was found for schizophrenics in Task #5. As in Task #4, this is most likely due to intentional or information processing deficits.

Schizophrenics were found to have increased response times over blocks of trials as in Task #4. Interestingly, this Block effect was found to be due to left visual half-field right hand and right visual half-field left hand increases in RT over blocks of trials. No left visual half-field left hand or right visual half-field right hand increases in response time were found over blocks. The one obvious factor here is that the two pathways necessitating inter-hemispheric transmission are the ones which increased over time. This is reminiscent of the research by Beaumont and Dimond (1973) which suggested "brain disconnection" in schizophrenia due to faulty corpus callosal connections. Schizophrenics made significantly more errors than normals on inter-hemispheric matching tasks. The results here reflect similar performance difficulties by schizophrenics in that slower response times were found for crossed responses and the left visual field-right hand responses revealed several incorrect discriminations. The disconnection hypothesis can not explain other results found in the current research. An information processing deficit can again be applied. Since no hemispheric preference was found for schizophrenics, precategorical processing most likely occurred. When Moscovitch (1977) studied precategorical processing, he found fastest RTs for left visual field-left hand and right visual field-right hand combinations. Possibly, due to slowed information processing allowing only enough time for precategorical stages, right visual field-left hand and left visual field-right hand performance increments are exaggerated as overall performance worsens over time. This imbalanced increment would be due to the extra time necessary for interhemispheric transmission.

Dysfunctional intentional mechanisms could result in similar difficulties of processing due to an initial delay caused by poor readiness to respond and a continued fatigue of this system over time. Why this differential half-field hand increase did not occur in the neutral task (Task #4) can only be accounted for by the increased task difficulty in Task #5.

When schizophrenics are divided into attentionally and non-attentionally deficited groups, the non-attentionally deficited group tended to have faster response times than the attentionally deficited. This non-deficited group, like the deficited schizophrenics, had no half-field preference but unlike the deficited group did not have increased responses over time. This suggests an intentional deficit in the attentionally deficited group which is compounded by fatigue of the system over time.

It is proposed that non-attentionally deficited schizophrenics have an information processing deficit, accounting for the lack of a half-field superiority. The attentionally deficited schizophrenics have both intentional deficits and slowed information processing.

In conclusion, mixed results were found for hypotheses:

(1) Controls performed as predicted on the neutral task, i.e. a right hemisphere superiority was found. This replicates and gives further support for right hemisphere dominance of intentional mediation. An unpredicted left visual half-field superiority for the verbal discrimination task may be further support for an overall right hemisphere dominance for intention or might be due to nonverbal processing of the material. A right hand and not a left hand response increase over

time on the neutral half-field task further supports a right hemisphere dominance for intention.

(2) Schizophrenics performed differently from controls, as expected. Generally, schizophrenics had overall slower reaction times than controls; no half-field effects were found for schizophrenics and increases in responses were found over time. These results were explained as giving support for either an intentional deficit or information processing deficits.

With the division of schizophrenics into attentionally deficited and non-attentionally deficited groups, results were generally as follows: non-attentionally deficited schizophrenics tended to have faster reaction times than the attentionally deficited schizophrenics; both schizophrenic groups showed no visual half-field preferences; and attentionally deficited schizophrenics produced increased responses over time. Non-attentionally deficited schizophrenics tended to have increased responses over time only on the neutral half-field task. Results for the attentionally deficited group can be interpreted as a combination of intentional and information processing deficits. Non-attentionally deficited schizophrenics are proposed as having an information processing deficit alone. Inconsistent performance by this group can be explained by a sampling effect. This group was comprised of only four members. Differences between the two schizophrenic groups do suggest that further examination of the non-attentionally deficited group would be helpful in understanding the components of schizophrenic deficits.

(3) Results of the simple reaction time, nonverbal CPT and verbal CPT indicated that the nonverbal visual tasks better differentiated

the schizophrenics from controls than the verbal task, although the verbal task did differentiate the two groups. This fits in well with hypotheses by Heilman and Van Den Abell (1979).

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In 1974 she began graduate school in clinical psychology at the University of Florida under a two year United States Public Health Scholarship. During her studies she became interested in neuropsychology and in 1977 completed her master's thesis on the topic of asymmetrical processing of the hemispheres. She spent her internship year, 1978-1979, in Houston, Texas. She then returned to Gainesville to complete her dissertation in December, 1981. Professional interests include neuropsychological and psychological diagnostic issues, psychotherapy and research of neuropsychological issues.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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